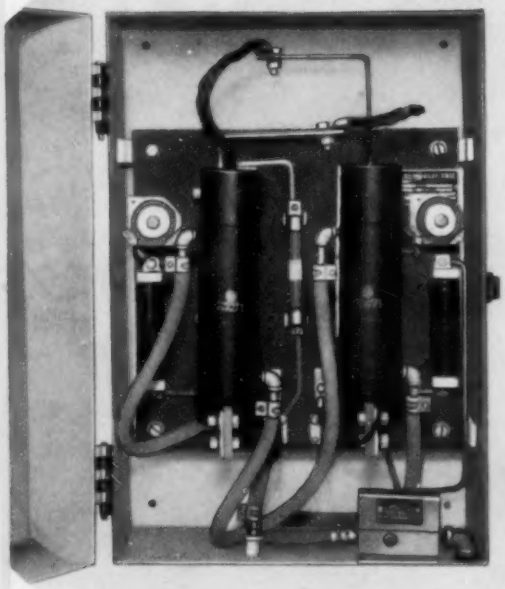
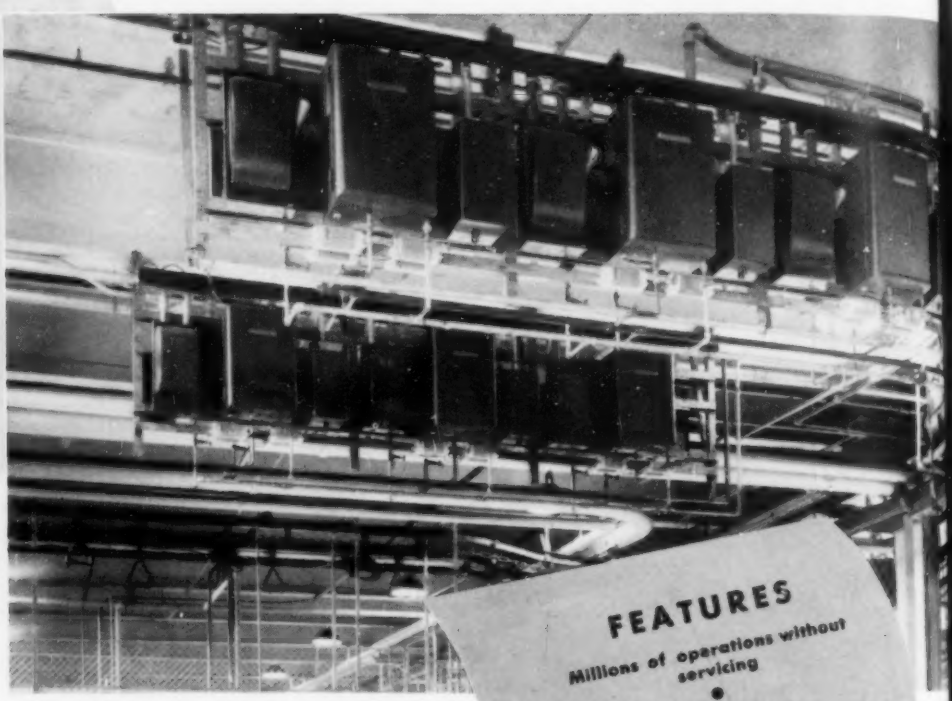
The Welding Journal

OCTOBER, 1939

The Journal of the American Welding Society

70 G-E IGNITRON CONTACTORS *Cut Welder Maintenance in Large Automotive Plant*





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W. SPRARAGEN, Editor

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Welding Operation on a 24-Inch Gas Line Header Having Six 8-Inch Nozzles. *Photo courtesy Crane Company.*

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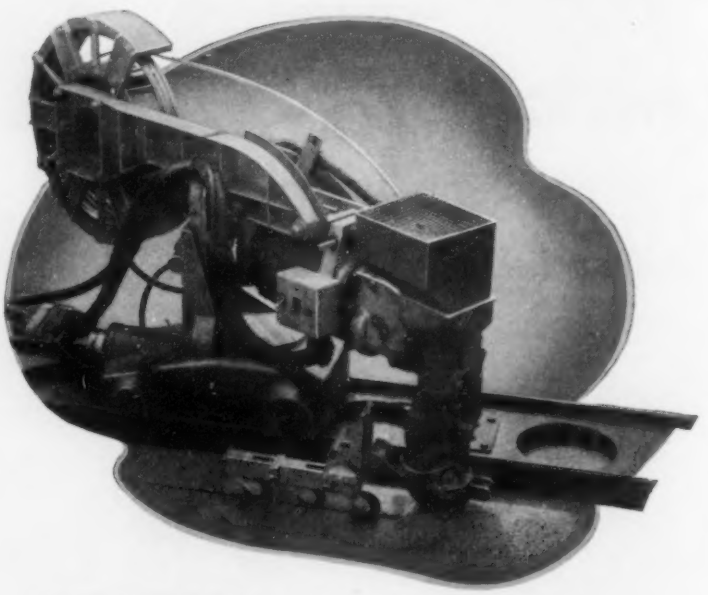

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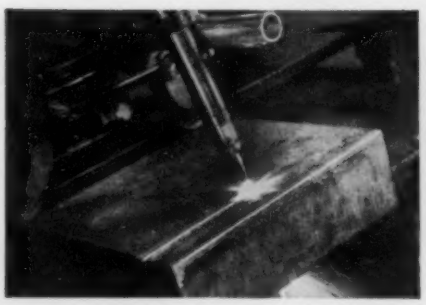

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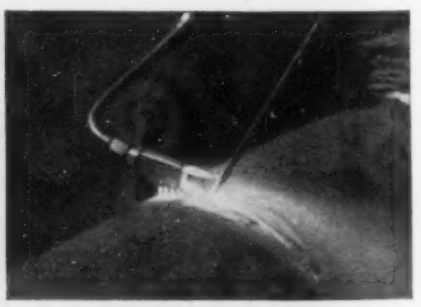

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Welding Journal

VOLUME 18, No. 10 OCTOBER 1939

PRECISION WELDING BY THE Resistance Method

A COLLABORATION

PHYSICAL REQUIREMENTS
GEO. J. OSWALD†

EQUIPMENT BALANCE
E. J. BATES†

FIXTURE DESIGN
R. L. HOUS†

PHYSICAL REQUIREMENTS

IN THE manufacture of complicated precision machines, methods of joining parts together becomes very important. Space limitations require maximum strength in joints of minimum size. The small size of many of the parts necessitates the designing of parts which will resist high stresses and repeated impacts.

For these reasons every improvement in methods of joining parts which produces space saving, strong, ductile joints, is of immense importance to manufacturers of such machines in improving their product. It will be evident from an examination of Fig. 1 why these space saving factors are so important.

Such an improvement has been accomplished through the developments in equipment for spot and projection welding. Machines with more accurate current and pressure control, electrode alignment, improved rigidity, as well as developments in mechanical and electronic timers, have eliminated the non-uniformity of parts produced on manually controlled equipment. This improvement in the uniformity of such welded construction is resulting in a widespread use of this type of fabrication among manufacturers where space limitations are not severe. This is due to the fact that they can use a sufficient number of welds to always have a large factor of safety. Where space limits the number of welds to but one, two or three welds, one must be much more careful. In fact with all of the improvement which has been made in welding technique, we have no method of inspecting the welds short of actually destroying them. The result is that where space limits the number of welds to less than two this type of construction is not approved. Where two spots can be used, the stress must not be such that more than one weld would be required, etc. Assuming such limitations we consider modern projection welding safe construction for machines such as ours. We have consequently refined some of our methods of fabricating parts and welding fixtures which may be of interest to other manufacturers.

Much has been written about the design characteristics of projection welding for parts of normal size. With this data we are familiar and in complete accord. However, much of this information is of little value when one is concerned with parts too small or too accurate to use standard size and type of projections. Likewise most of the data pertaining to spot welding is of little value to such manufacturers. These conditions exist mainly because of the distortion and strain which is introduced in making and using projections of the normally recommended dimensions. If our experience in fabricating accurate assemblies, which must be held to limits of 0.001 inch, has added anything of value to the art of projection welding, it has been in adopting a practice of using smaller, more accurate projections and a welding technique which produces maximum strength of joint without undue distortion of parts.

In developing this practice it has been necessary to obtain certain refinements in welding machines. Also to adopt precision toolmaking practice in building locating welding fixtures. This development of equipment and fixtures will be described in subsequent sections of this paper. This projection welding practice has in a number of cases replaced such practices as riveting, dowel pinning, copper brazing, etc. It is well known that riveting and pinning cause distortion of parts even though these operations are carefully performed. Copper brazing has the serious disadvantage of completely annealing the parts, and in some cases, of requiring rehardening which in turn again results in distortion. Projection welding as described herein will produce more accurate assemblies than the methods of assembly formerly used and will not reduce hardness or strength of the parts.

The materials used in manufacturing our parts have commercially clean cold rolled and cold drawn or machines surfaces. It is therefore possible to use lower projection height and lower welding pressures than if rust or scale were present. It is interesting at this time to consider briefly the projection design commonly recommended for gages of stock we normally use. Dimensions of these projections are given in Table 1.

We were never able to use such large projections satis-

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.

† The National Cash Register Company, Dayton, Ohio.

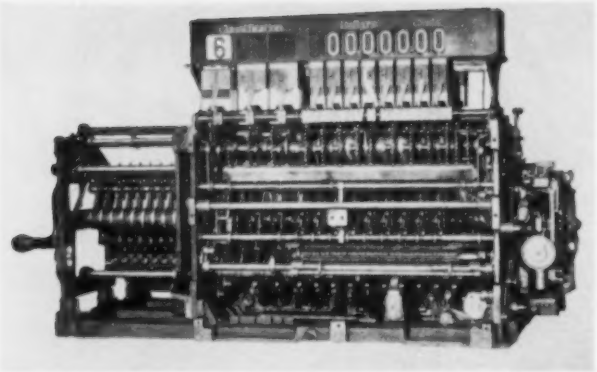

Fig. 1—Space Factors Are Important in These Types of Machines

factorily because of the enormous amount of distortion they introduced in our parts. This distortion took place when the projections were being made and when they were being welded. However, we approached these recommended dimensions as closely as possible and started our projection welding by using projections approximately 30% smaller than shown in Table 1. Even

Table 1—Projection Dimensions in General Use

Gage	Thickness	Projection Height	Projection Diam.
9	0.156	0.050–0.060	11/64
10	0.140	0.050–0.060	11/64
11	0.125	0.050–0.055	11/64
12	0.100	0.050–0.055	11/64
13	0.093	0.045–0.050	11/64
14	0.075	0.045–0.050	11/64
15	0.070	0.040–0.045	11/64
16	0.062	0.040–0.045	11/64
17	0.056	0.035–0.040	5/32
18	0.050	0.035–0.040	5/32
19	0.043	0.035–0.040	5/32
20	0.037	0.030–0.035	1/8
21	0.034	0.025–0.030	1/8
22	0.031	0.025–0.030	1/8
23	0.028	0.020–0.025	7/64
24	0.025	0.020–0.025	7/64

with such projections, distortion in piercing, loss of location in welding due to shifting, twisting, buckling, etc., discouraged the use of this method of assembling for accurate parts. The parts were amply strong, but we were seriously advised that the use of smaller projections would result in shallow welds and decided loss of strength. As we had not experienced serious loss of strength by the first reduction of 30% in projection size, and since the welded section was always stronger than the surrounding material, we decided to see what would happen by drastically reducing the size of the projections, especially the height. Consultation with production departments disclosed that they were much in favor of reducing projection heights to approximately 0.010 inch since this would permit them to make such projections with no distortion of parts. It also seemed that welding heats and pressures could be reduced with consequently less shifting of parts in the fixture, increased electrode life, lighter fixtures, etc. Consequently certain tests were started to determine if this would be practical.

In order to study some of the factors affecting the strength and ductility characteristics of projection welds a welded test specimen which could be tested in a tensile testing machine and one which could be tested in torsion were used. The tensile specimen was made of two pieces of Hard Cold Rolled Strip Steel (S. A. E. 1010) each 11/16 inch wide, 5/32 inch thick and 5 inches long. These were lapped with a 1-inch lap and a single weld was placed in the center of the lapped section. They were held in a jig to secure correct alignment while being welded. Material 5/32 inch thick was used, although this is heavier than the stock from which most of our welded parts are made, in order to secure the following advantages.

1. Sufficient thickness to provide space for a deep weld.
2. Rigidity in test specimen to subject weld to shearing stresses rather than tearing stress.
3. To force the fracture to occur in the weld.

A series of tensile specimens were welded using projection heights of 0.010, 0.020, 0.030 and 0.040 inch, keeping the diameter constant at 1/8 inch.

The machine used in welding these specimens was of 150 kva. capacity. It was arranged so the movable electrode could be brought into gentle contact with the work by air pressure. The forging pressure was applied by spring pressure at the same time the heat was applied. This forging pressure was maintained until after the timer cut off the welding current or heat. The transformer was arranged to provide 64 steps for current control. Two types of electronic timers were available for current time control. In general, the current-time relationships which gave best results were those of relatively low current values and longer times, rather than those of high current values and short times. It was found that time values of 16 to 32 cycles gave best results and current values were adjusted to heat the work as hot as possible during this time without marring the work.

Fig. 2—Spot-Welded Section in Low Carbon Steel 0.050 Inch Thick. Projection, 1/8 Inch High

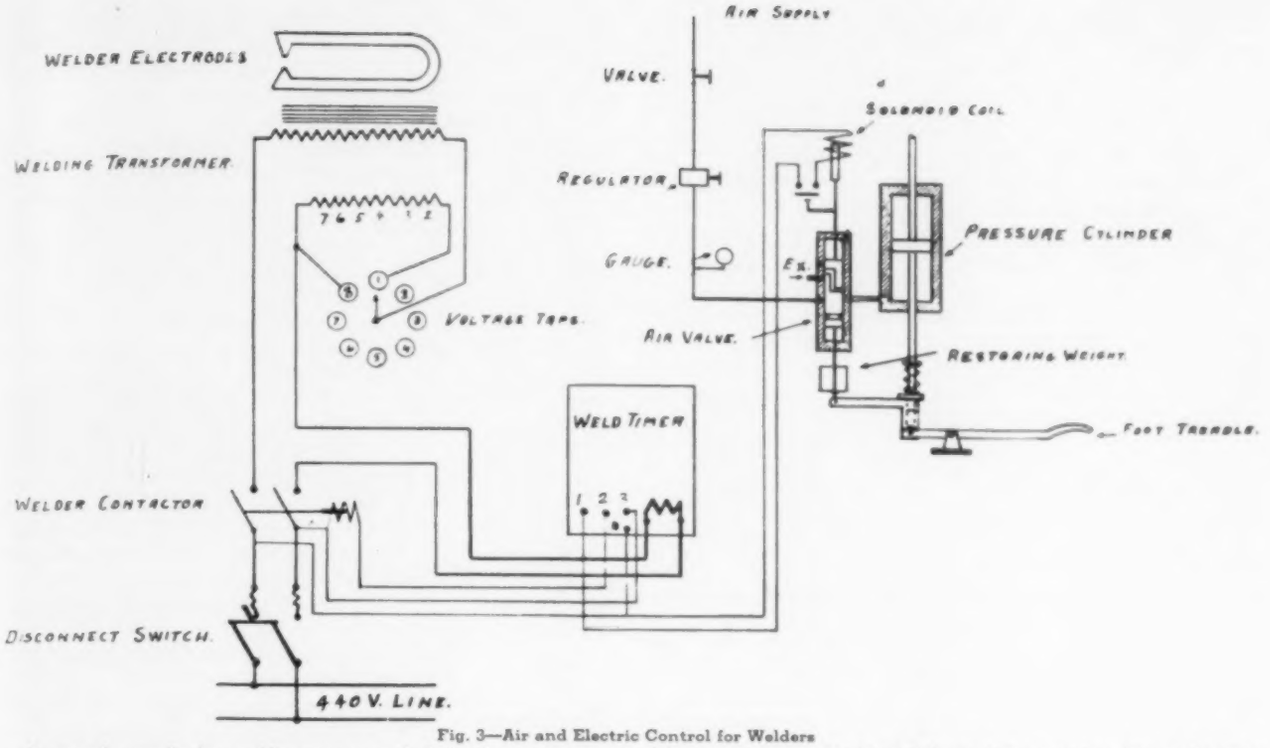

Fig. 3—Air and Electric Control for Welders

Depressing foot treadle closes welding points on work; further depression opens valve, letting air into pressure cylinder which forces plunger up to a predetermined pressure. When air valve reaches full open position switch contacts are closed that starts the cycle of operation. Valve holding solenoid holds valve in open position until timer completes operating cycle.

Pressures of approximately 50,000 lb. per square inch were necessary to properly forge the smaller projections as compared with pressures of about twice that much for the larger projections.

The results of the tests on the tensile specimens were as follows:

Height of projection	0.040 in.	0.030 in.	0.020 in.	0.010 in.
Diameter of projection	1/8 in.	1/8 in.	1/8 in.	1/8 in.
Average weld strength in lb.	5300	4980	4500	3800
Variation below average	5%	5%	11%	6%

The difference in weld strength was apparently due mainly to the difference in weld area as the higher projections under more heat and pressure were forged down over larger areas. When the results of this simple test are studied on the basis of comparable weld areas, some rather surprising facts can be brought out. Reducing the above values to weld strength per unit of weld area we find the following results:

Height of projection	0.040 in.	0.030 in.	0.020 in.	0.010 in.
Diameter of projection	1/8 in.	1/8 in.	1/8 in.	1/8 in.
Average weld strength in lb.	5300	4980	4500	3800
Area of weld sq. inch	0.188	0.166	0.160	0.131
Weld strength per unit of area, lb. per sq. inch	27,700	30,000	28,100	29,000

These values per unit of area prove that the strength of the weld depends upon the effectiveness of the grain growth and recrystallization across the joint of the weld. The size of the area covered by this grain growth and recrystallization is the most important factor in determining the strength of the weld. The forging action of heavy pressures is of major importance in increasing the size of the weld area. Since the lower projections required less pressure than the higher projections and since the strength per unit of weld area were approximately the same, it would seem that the pressure need be sufficient only to break through any film, which may be present on the surfaces to be welded, and to force the metal into intimate contact for a sufficient length of time for such grain growth to take place. This theory would indicate that the heavy forging pressures usually used in projection welding are somewhat overdone and may even be unnecessary in welding light weight parts having commercially clean surfaces.

The next step was to determine whether the weld area could be increased by increasing the projection diameter, but retaining the height at 0.010 inch, without unduly increasing the amount of heat and pressure. In other words to attempt to secure the same weld area or strength as that produced by the 0.040-inch projection but at lower heat and pressure values. Some samples were then welded using projections 0.010 inch high and 5/32 inch diameter as we had evidence that the 5/32 inch diameter produced a welded area of 0.181 square inch, which was approximately the same weld area produced by the 0.040 inch x 1/8-inch projection. Current, time and pressure were the same as used on the previous test. Results of the tensile test were as follows:

Height of projection	0.010 in.
Diameter of projection	5/32 in.
Average weld strength in lb.	4120
Area of weld sq. in.	0.181
Weld strength per unit of area, lb. per sq. in.	22,700
Variation below average	7%

It will be seen that increasing the diameter of the projection from 1/8 inch to 5/32 inch increased the strength of the entire weld but reduced the weld strength per unit of area. The welds were uniform but had the appearance of insufficient heat as there did not appear to be the proper grain growth across the joint. Consequently a series of tests was run to determine how much the heat could be increased without developing too much pitting or marring of the work.

Keeping the time and pressure constant and increasing

the heat gradually we found weld strength values changed as follows:

Heat No. 8—4210 lb. average weld strength
Heat No. 9—4830 lb. average weld strength
Heat No. 10—4930 lb. average weld strength
Heat No. 11—5120 lb. average weld strength
Heat No. 12—5240 lb. average weld strength
Heat No. 16—6260 lb. average weld strength

The weld strength had increased with the heat used. However, the maximum heat permissible without pitting or marring of the work was No. 9.

Another series of specimens using this heat and projections 0.010 inch high, with $^5/_{32}$ inch diameter, keeping pressure constant at 50,000 lb. per square inch and time as previously used, was welded and tested with the following results:

Height of projection	0.010 in.
Diameter of projection	$^5/_{32}$ in.
Average weld strength in lb.	4737
Area of weld sq. in.	0.181
Weld strength per unit of area, lb. per sq. in.	26,100
Variation below average	5%

In view of the practical limitations in adjusting heat pressure and time, this result was close as we could come to the results obtained with the 0.040 inch x $^1/_8$ inch projections. However, for practical use these results are reasonably close.

In order to be sure that lower pressures were actually required on the lower projections than on the higher ones, a check test was run on the original series of specimens, namely those having projections 0.040 inch, 0.030 inch, 0.020 inch and 0.010 inch high. All of these projections were of the $^1/_8$ inch diameter except the ones which were 0.010 inch high, and these were $^5/_{32}$ inch in diameter. The set-up for pressure, current and time was the same as that which gave the best results on the 0.010 inch x $^5/_{32}$ inch projection. Results were as follows:

Height of projection	0.040 in.	0.030 in.	0.020 in.	0.010 in.
Diameter of projection	$^1/_8$ in.	$^1/_8$ in.	$^1/_8$ in.	$^5/_{32}$ in.
Average strength of weld in lb.	4440	4620	4553	4737
Variation below average	25%	5%	11%	5%

These results on the higher projections gave poor values mainly because the pressure used was insufficient to completely forge the higher projections, consequently the component parts of the specimen were not in intimate contact. This is further evidence that lower pressures can be used with the lower projections of diameters of sufficient size to result in welds of equivalent areas and strength normally characteristic of the higher projections with consequent higher pressures.

Some further testing was done to determine the ductility of welds resulting from the use of the 0.010 inch x $^5/_{32}$ inch type of projection. Thinner stock of 0.050, 0.062 and 0.072 inch thicknesses was used. The test specimen consisted of two pieces of S. A. E. Cold Rolled Strip Steel, hard temper, $^1/_2$ inch wide by 2 inches long. They were welded in the form of a +, with the weld at the center of intersection of their longitudinal axes. The welding was done in a jig to secure proper alignment. After welding these specimens were tested in a torsion machine in a fixture made in the form of a Hooke's joint, using the welded specimen for a connecting member. This type of test was used because spot or projection welds will pull out slugs of metal in thin stock if the welds are at all good. Torsion tests are more effective in breaking the welds and the degree of twist gives a good indication of the brittleness or ductility of the weld.

Hundreds of specimens were tested using many combinations of current, time and pressures. However, the most successful welds were made with combinations similar to those given in Table 2.

Such strength values and uniformity place the lower, wider, projections on comparable basis with the higher type of projection generally used. This is especially true when it is realized that most of our welds are used in light weight parts made from 0.025 to 0.125 inch stock and in such parts, welds of this type would not fail before the parts themselves were permanently deformed or destroyed. The above tests on case-hardened, carburized and hardened, and the carburized, welded and hardened specimens were run to determine whether large variations in carbon content would seriously affect the weld strengths. Also whether drastic treatments such as heating and quenching after welding would reduce weld strength and ductility. It would appear that ductility is affected by drastic treatments such as these. The plated specimens likewise affect ductility. A satis-

Table 2—Strength Values Are Given in Inch-Pounds at the First 5° Deflection, Then the Maximum Inch-Pound, Reached and the Deflection at Which It Was Reached

Material	Cycles	Heat	Lb. Pressure	Scar	Flash	Discoloration	Inches Lb. @ 5°	Max. Inches Lb.	Deflection @ Max. Lb.	Remarks
0.062 In. (S.A.E. 1010) C.R.-Hd.	16	28	900	None	None	Some	210	415	45°	Slug pulled out
0.062 In. (S.A.E. 1010) C.R.-Hd.	16	28	1000	Slight	Slight	Some	220	445	40°	Slug pulled out
0.062 In. (S.A.E. 1010) C.R.-Hd.	32	27	800	"	"	"	215	500	45°	Slug pulled out
0.062 In. (S.A.E. 1010) C.R.-Hd.	16	27	800	"	"	"	215	400	45°	Weld sheared
0.062 In. (S.A.E. 1010) C.R.-Hd.	32	26	700	"	"	"	215	470	45°	Weld sheared
0.062 In. (S.A.E. 1010) C.R.-Hd.	32	24	600	"	"	"	220	380	35°	Weld sheared
0.062 In. (S.A.E. 1010) C.R.-Hd.	32	28	1000	"	"	Bad	235	500	25°	No failure
0.062 In. (S.A.E. 1010) C.R.-Hd.	32	28	900	"	"	Some	335	500	20°	Weld sheared
0.050 In. (S.A.E. 1010) C.R.-Hd.	32	21	900	"	"	"	200	435	40°	Weld sheared
0.050 In. (S.A.E. 1010) C.R.-Hd.	32	21	900	"	"	"	195	400	40°	Slug pulled out
0.072 In. (S.A.E. 1010) C.R.-Hd.	32	21	900	"	"	"	200	495	35°	Weld sheared
0.072 In. (S.A.E. 2315) C.R.-Hd.	32	21	900	"	"	"	210	500	30°	No failure
0.062 In. C.R-Hd. Temp.-S. A. E. 1010 Case Hd. 0.005 In. Deep	32	21	800	Some	Some	"	220	440	30°	Slug pulled out
0.062 In. C.R.-Hd. Temp.-S. A. E. 1010 Car. & Hd. 0.015 In. Deep	32	21	900	Slight	Slight	..	240	500	11°	No failure
0.062 In. C.R.-Hd. Temp.-S. A. E. 1010 Car. Wld. Hd.	32	21	900	"	"	Some	230	500	12°	Weld sheared
0.062 In. Nickel Plated	32	28	900				135	500	20°	Weld sheared
0.062 In. Copper Plated	32	35	900				180	500	15°	Weld sheared

420134

SPOT WELDING INFORMATION Drawing No. B-14674 Insp. No.

Class 2060 Name of Part TOTALIZING LEVER "C" Model Location

Fixture and Electro Order Numbers P.E.-30855

OPERATION	KIND OF MACHINE AND K.V.A.	PRESSURE SETTING	TRANSFORMER	TIMER	KIND OF ELECTRODES	WELDING ASSEMBLY OPPOSITE SIDE
A 306	75	600	10	G-L.	MALLORY 3	SKETCH IF NECESSARY
B					5/8 Top 1/2 Lower	
C						
D						

Material Specifications 3½% Ni. Steel Block welded to ¾ Hard P.S.

Remarks Totalizing Lever. Two projections on Block 5/32 Diam. -.010 High

Research Approval H.S. Osmond Date 11-22-37 Punch 2 Approval P.P. Eldridge

Fig. 4.—Specification Card

factory weld in S. A. E. 1010-0.062 inch thick after testing is shown in Fig. 2. This weld was made from a projection 0.008 inch high x 5/32 inch diam. It was tested in tortion and required 500 in.-lb. to cause failure at a deflection of 45°. This is the type of weld we have adopted as standard for our parts. However, in exceptional cases where the stock thickness and rigidity permit, we do use larger projections.

EQUIPMENT BALANCE

Spot or resistance welding has been done by the N. C. R. Co., since around 1912 or 1913. For a number of years this was only done on cabinet parts on which a number of welds could be made and the failure of any one of two or more did not in any way effect the finished product.

These old welders of various makes ranged from 12.5 to 25 kva. rating and were operated by a foot pedal which applied the pressure to the electrodes and controlled the switching of the current. The success of the weld was wholly determined by the skill of the operator and most operators of that period did not think a weld was any good unless he got considerable spattering of metal.

We soon found in trying to projection weld operating parts where it was impossible to have more than a few welds in a part that to get the necessary uniformity and strength, we must (1) Remove as far as possible the human element, (2) Increase electrode pressures and (3) Balance all equipment electrically, so that the same results could be obtained on any welder on the floor that the job may be placed on.

The human element was removed by equipping these welders with electric timers for control of current and air cylinders and gages for the increase and control of pressures. These are so arranged that the completion of the weld is entirely automatic after being started by the operator (see Fig. 3).

The welders were balanced electrically by making open circuit voltage curves on each welder of the same rating as near as possible and have the higher voltages on the smaller welders the same as the lower voltages on the larger welder, or make the voltage curves from the smallest to the largest welders overlap.

Current curves were also plotted for each welder through a known resistance and these also balanced. To accomplish this it was found necessary to rewind several of the transformers and also to make the throat area practically the same so as to balance the secondary reactance.

Timers used are the current measuring type. These were adopted after comparative tests were made with two different makes of definite time timers that were available at that time. These tests showed that the current measuring type of timer gave us more uniform results on our type of work.

Strength of weld varied as follows for different time settings on the two types of timers. Two different makes of definite type timers were used in this tryout.

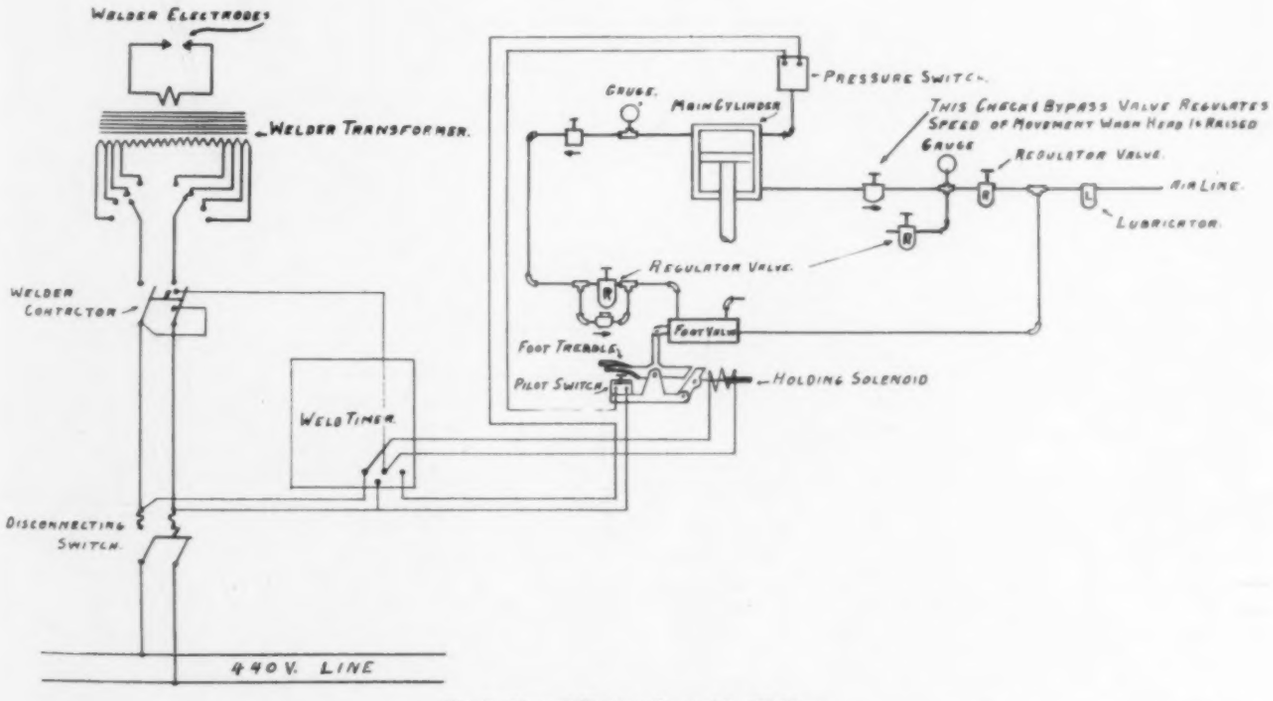

Fig. 5—Air and Electric Control for Welders

By depressing the foot treadle on foot valve, operator has full control of ram movement on machine, either downward or upward. By completely depressing foot treadle, the operator trips the pilot switch which actuates timer, after pressure switch is closed. Timer actuates contactor and solenoid on foot valve, which holds treadle down until timer disconnects welding circuit, opens control circuit, releasing foot treadle hold down and spring shifts valve to opposite side and ram automatically returns to starting position.

		Current Measuring	Definite Time No. 1	Definite Time No. 2
(1)	Shortest time setting	8%	18%	21%
(2)		5%	21%	25%
(3)		5%	3%	29%
(4)		2%	2%	3%
(5)	Longest time setting	5%	2%	2%

This definitely shows that with good clean stock that on the longer settings that the two types of timers are equal, but on the faster settings the current measuring type has an advantage on our type of work, possibly because it automatically changes the time when resistance varies slightly.

After all of the above changes were made on the equipment, it has been possible to have specification cards on each production job, see Fig. 4, giving the transformer tap, timer setting and pressure to be used, and regardless of which welder of the group the job is placed on, the results are duplicated. This removes all guesswork from the production departments operators and insures duplication of welds.

All welding equipment that we have installed during the past few years must meet with specifications embodying all of the features described that have been found necessary for the precision required by our work.

Figure 5 is the control method used on our latest welders.

Figure 6 shows a section of our most recent installation.

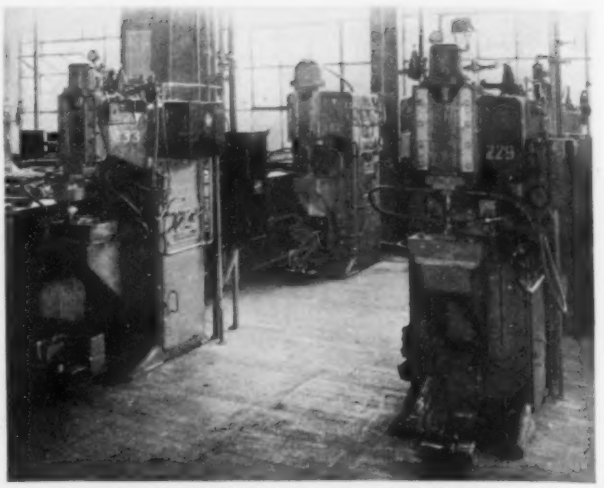

Fig. 6—A Section of a Recent Installation

FIXTURE DESIGN

The object of using jigs and fixtures in resistance welding is identical to their use in drilling, milling and other machine tool operations. It is only through their use that extreme accuracies can be maintained. The following rules are set up for the guidance of the designer in working out details of resistance welding fixture construction.

1. *Keep All Magnetic Materials (Iron & Steel) Out of the "Loop."*—By "loop" is meant the gap surrounded by the upper and lower arm, the electrodes, and the base of the machine housing the transformer. The presence of iron or steel in the "loop" chokes the available welding or heating current back from the electrodes, making for poor efficiency of the welder. All parts placed in this "loop" or space must be non-magnetic.

2. *Keep This "Loop" or Space Described Above as Small as Possible.*—This space, sometimes called throat gap, is the cause of many disappointing results in setting up and installing fixtures, for many times a 24 inch or longer throat machine is used where a 12 inch or even smaller throat could be used to a much better advantage. Also over-all height of welding fixtures should be reduced to a minimum. All this again makes for more welding efficiency and makes possible doing jobs that may seem too heavy for the machine, eliminating excessive losses due to increased reactance and lowered power factor of the machine.

3. *Make All Welding Electrodes Easily and Quickly Replaceable and Water Cool Them as Close to the Tip as Possible.*—In most every case of projection welding fixtures the standard copper-tungsten electrode tip can be used. These are readily obtained and inexpensive to replace. The inlet water tube should be large enough to prevent plugging up—$^{3}/_{16}$ to $^{3}/_{8}$ inch inside diameter depending on the job.

4. *Insulate All Gage Pins, Clamps, Locators, Index Pins, etc.*—In all jigs or fixtures where locating pins touch the work they must be insulated from the work by being pressed into a fiber, bakelite or other insulating material sleeve having projection shoulders which in turn is pressed into the base of the fixture. When a gage pin or stop touches both pieces of work being welded, it should be of aluminum bronze or some similar material, for electric current shunting across the pin has no respect for the hardest of alloy steel and will pit and burn it, whereas a bronze pin will not offer resistance to cause the current passing through it to arc. This will prevent burns.

5. *Provide Sufficient Cross Section to Current Carrying Members and Run as Close to the Electrodes as Possible. Use as Few Breaks or Connections in the Circuit as Possible.*—When we consider the characteristics of welding current, we immediately see the necessity of this. A welding current is extremely high in ampere capacity and carries from 1 to 15 volts depending on the machine and the job, and a pure copper conductor cannot carry more than 1200 or 1500 amperes per square inch, and if water cooled, will carry 1500 to possibly 2000 amperes per square inch. If the conductors are too small, overheating will result and the fixture will be useless unless these conductors can be enlarged. And again if a welding fixture were built in sections the loss of current (commonly known as voltage drop) passing from one section to another would be too great to have enough left for welding.

6. *All Moving Slides, Bearings, Index Pins, Adjusting Screws and Any Accurate Locating Device Should Be Protected from Flash.*—This is particularly necessary when as many as 200 to 4000 welds are made per hour. Flashing can cause a lot of trouble getting across insulated pins, causing a direct electrical short, or into slides, making repairs necessary.

7. *Provide Adjustment for Electrode Wear.*—Most electrodes for projection welding are copper-tungsten or the precipitation hardening copper alloys, and after a production run wear down a distance that the stroke of the welder will no longer maintain a welding pressure contact between the electrodes and the work. They must be adjusted either by raising the entire lower arm or fixture or replacing with refaced or new electrodes. Not only must adjustment of electrodes be provided to maintain a constant welding pressure on the work at all times, but stops, gage points, pins, etc., must also compensate or be large enough surface to gage the work at both new and worn out electrode height.

8. *Check Welding Pressure Application.*—Since the welding pressure application to a piece of work has a direct effect on the weld, the design of the fixture must take into consideration the following:

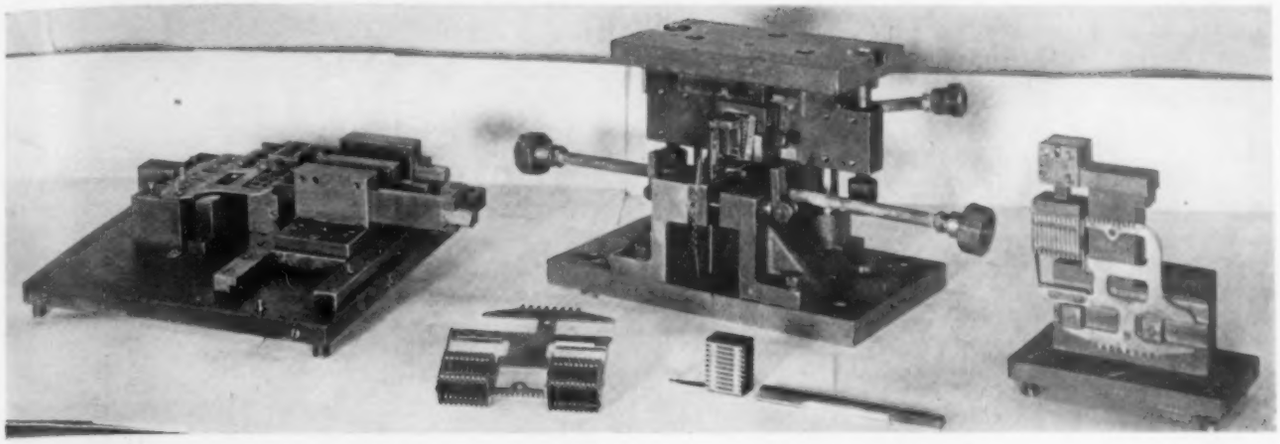

Fig. 7—Typical Projection Welding Fixture. Its Gages and Product

(*a*) Accuracy in the machine work for projection welding fixtures and electrodes, and

(*b*) The elimination of deflections due to the welding pressure, so the upper and lower electrodes are parallel with each other in all directions and remain so when final welding pressure is applied.

9. *Ease of Operation and Protection for the Operator.*—As is common to all jigs and fixtures for any machine, ease in loading and unloading must be taken into consideration. One feature of a welding fixture that is not common to fixtures for other machines is that a welding fixture must be designed and built to accommodate the loading of usually two or more separate parts that become, after the welding operation, only one piece that must be unloaded Care must be taken that a welding fixture or jig will unload properly when the parts are welded. The danger to the operator when loading and unloading fixtures and jigs from the standpoint of electrical shock, is very remote providing there is no primary short in the machine. The secondary current, or welding current, is of very low voltage and is entirely safe even though the secondary circuit is unprotected. However, for the operator's protection only one side of the secondary circuit—either above the top electrode arm or below the fixture base—should be insulated from the base of the machine. The welding machine should also be grounded so if a primary short develops in the transformer controls, it will be positively grounded through the welding machine and not through the operator, as would be the case if both sides of the secondary circuit were insulated from the machine base and the operator was touching both upper and lower electrodes or electrode supports. Further protection for the operator's hands should be taken into consideration by providing guards on hand loaded electrode dies.

10. *Be Sure the Fixture or Jig Is Suited to the Job and the Machine.*—As stated in a former paragraph, all phases of possible welding operations should be considered as well as the machine to be used, and the number and size of pieces to be welded. All have a direct bearing on the type of fixture used. When the method of welding is determined, time should be taken to completely check the parts to be welded so as to provide for sufficient electrode surface and clearance. Be sure that the welds are in the best possible position, that the stock specified is weldable, that necessary provisions are made for clamping and locating and that the correct size and shape of projections are used.

To determine the above, several sample welds should be made either on the machine to be used with the fixture or jig, or a similar machine, from which sufficient data can be obtained to specify the machine required. Allowances should be made, of course, for the new arrangement and the speed of welding.

11. *Provide Sufficient Water Cooling.*—This very important rule is usually very much neglected and brought forcibly to attention through overheating, excessive electrode wear, transformer burnouts, etc.

On a high production job where electrodes are welding with each stroke of the machine, running continuously, an individual and separate water cooling line should be provided for each electrode. A sight drain pot should be provided and inspected frequently to insure a flow of cool water. Regulating valves should be provided to adjust this water flow to prevent waste. Various types of water cooling should be considered. Water cooling through troughs cast in the sides of the fixture or fixture support provide much more water cooled surface than a drilled hole. Cast in copper pipe or tubes in copper castings should be used where various angles or bends of the cooling paths are necessary. The casting of steel tubes into copper castings, for cooling, should be avoided as it is an inferior method. In the case of small jigs to be handled frequently, there should be several provided so they will be used at sufficient time intervals to allow them to cool sufficiently between welds to permit them to be handled.

12. *Knockouts or Strippers.*—In a welding fixture or jig for heavy welding or when the stock may not always be clean, there is a tendency for work to stick to the electrode faces. This should be taken into consideration where progressive jigs are used, also when automatic or quick loading and unloading of the work is desired. Knockout pins, operated through a leverage, or a position stripper, save considerable production time and add to the operator's protection.

13. *Stationary Parts of Fixtures and Work Affected by Magnetic Field of Machine.*—The magnetic pull of a welding machine toward the transformer is frequently of such intensity as to lift small pieces of work out of their locators. Small eccentric clamps made of steel when sufficiently close to the "loop" to be affected, are sometimes actually released by this force. Work holding plates and clamp handles of non-magnetic material will prevent this condition.

The above are general rules applying to most fixtures for resistance welding. It would be impossible to cover in detail the design and operation of projection welding fixtures and locators, etc., as each and every job has its own characteristic and application. Figure 7 is a typical projection welding fixture, its gages and its product.

FLAME DESCALING AND Flame Cleaning and Dehydrating*

By J. G. MAGRATH†

INTRODUCTION

GRADUAL recognition that thermalscaling of ferrous metals is a cause of both manufacturing and surface treatment difficulties has resulted in rapidly spreading interest in means for the swift removal of surface accumulation of this kind. The presence of scale on steel billets in the steel mill prevents close inspection for the locating of minute defects and fine seams prior to flame scarfing or chipping.

On structural steel, the loosening and flaking off of mill scale, taking the paint with it, has been the cause of considerable discussion between fabricators of structural steel and manufacturers of paint over a period of years. Where such conditions occur, the steel is fully exposed to atmospheric oxidation prior to finish-painting and opportunity is provided for moisture to find its way between the remaining scale and steel, remaining after finish-painting, and continuing its destructive action so that frequently within a year or so, inspection shows large areas of exposed steel, atmospherically oxidized. Heavy maintenance costs are the result.

Frequently heavy or hard scale on forgings and steel castings is damaging to cutting tools in the first machining cut and sometimes conceals defects that may later cause failure.

The subject of high temperature scale formation has been discussed in an earlier paper by the writer entitled "Iron & Steel Descaled & Structural Steel Cleaned & Dehydrated by Oxyacetylene Process."‡ In that publication, the various layers namely ferric-oxide, magnetite and Wüstite were fully described in their relation to each other and the conditions under which they might be formed. In this paper, we will treat solely with the applications of the oxyacetylene flame descaling and flame cleaning and dehydrating processes.

IN THE STEEL MILL

In flame descaling billets, slabs, rounds, bar-stock, blooms and ingots in the steel mill, the process employs the use of the oxyacetylene torch in combination with brush-type tips, on extensions, which are positioned so that the enveloping flame completely covers the scaled surface for the width or expanse of the tip flames. These tips are mounted on wheeled carriages or hard-faced skids and are traversed over the surface at the proper rate of speed to remove the maximum amount of scale. This speed will range from 10 to 20 linear feet per minute. By means of the high temperature thus applied the scale is rapidly heated without overheating the base metal. A differential expansion results, causing the scale to lift, crack and fly off in particles ranging from

Fig. 1—Flame Descaling Steel Billets. Flat Multi-Flamed Oxyacetylene Tips Mounted on Hard-Faced Steel Skids. Right-Angle Assemblies on Skids May Be Provided for Descaling Two Faces of Billet, One Vertical and One Horizontal at One Pass

$\frac{1}{16}$ to $\frac{1}{4}$ inch in cross dimension on billets, bars, rounds and slabs and from $\frac{1}{8}$ to 1 inch cross dimension on forgings and steel castings.

While the Flame Descaling process has not been developed to the stage providing for complete scale removal on all grades of higher alloy steels, it is found to serve satisfactorily for the greater volume of common grades of carbon and low alloys. In this service it reduces the tonnage passing through the pickle and thus the amount of pickle waste ultimately to be disposed of. The process may also be used to supplement the pickling operation in that the greater amount of loose scale may be flame descaled and the remaining lesser amount removed in a brief pickle with acid of reduced strength.

Flame Descaling leaves a natural surface. Artificial resurfacing found in various other scale removing procedures is absent. A surface is disclosed which, to the untrained eye, is not recognized at first long range glance as being a "clean" surface. Close examination however will disclose that when the scale has been removed by flame descaling, the true unaltered surface of the metal is exposed. There is no chemical or physical action upon, or discoloring of, the base metal. The process is rapid and is one that can be fitted into a production line.

IN STEEL FOUNDRIES AND FORGE SHOPS

On steel castings and forgings, the oxyacetylene flame descaling process rapidly heats the high temperature and annealing scale without materially heating the base metal and causing unusual stresses to develop. While scale on steel castings will generally free itself in particles of $\frac{1}{64}$ to $\frac{1}{8}$ inch in thickness, and from $\frac{1}{8}$ to 1 inch in cross dimension, forging scale may range to $\frac{3}{16}$ inch in thickness and break free in particles of $\frac{1}{4}$ to $\frac{1}{2}$ inch in cross di-

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† Air Reduction Sales Company, New York, N. Y.

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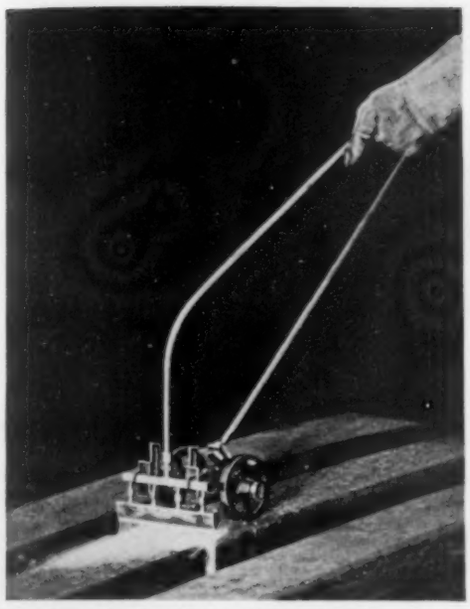


Fig. 2—Flame Descaling Steel Billets. Flat Multi-Flamed Oxyacetylene Tips Mounted on Wheeled Carriage. Right-Angle Assemblies on Wheeled Carriage May Be Provided for Descaling Two Faces of Billet, One Vertical and One Horizontal, at One Pass

mension. Steel casting scale will as a rule free itself completely down to the scale-steel interface with one pass of the flames, whereas forging scale may break free in two or more layers, requiring a second pass of the flames after the surface has sufficiently cooled from the first pass.

A round tip is generally accepted as a universal tip for forgings and steel castings. Its double circular group of neutral clear-cone flames provides a large volume of concentrated heat. It may be used on flat or irregular surfaces and for projections, corners and remote recesses. Ordinarily the tip is held in a vertical or near-vertical position about 2 inches from the work, and, swinging sideways right and left for a spread of about 12 inches, progressively moved in a forward direction. Some of the very tenacious scales may require that the tip be held closer to or against the work at an angle of about 45 degrees. A hard-faced annular protective and wearing ring is provided on the tip for this purpose.

Where very large steel castings provide large flat areas, an opportunity is presented to use a broad flat multi-flame tip to advantage. This style is available in widths ranging from 2 to 12 inches in 2-inch accruements and consists of a row of close formation small brush-like flames. Tips are mounted on renewable steel hard-faced wearing skids, and are guided across the surface at a forward speed of 5 to 10 linear feet per minute, and at a flame impingement angle of approximately 45 degrees.

Where the flame descaling process is employed in the foundry or forge shop, it offers numerous advantages. A natural surface is secured as there is no graining, indentation or chisel marking. Defects, seams and fissures are exposed. The process is comparatively quiet and is safe in that there is very little dust and it flies no considerable distance. It may be conducted in areas adjacent to other plant operations thereby eliminating handling or re-handling costs. Size of object is not a limitation. Castings weighing from 1 pound to 100 tons or large may be flame descaled. The flames will reach remote crevices and deep openings as the apparatus is very flexible. There is no chemical or physical action upon or discoloration of the base metal and where painting follows on castings or forgings, the beneficial action of surface dehydration is obtained.

STRUCTURAL STEEL IN SHOP AND FIELD

The oxyacetylene Flame Cleaning and Dehydration process is new and at present is being subjected to practical tests under normal conditions on erected steel bridge structures in the East. The process is based, promoted and accepted upon the theory that:

(*a*) Occluded moisture within and beneath the scale and on the surface of the steel creates a condition favorable to the progressive loosening of the tenacious mill scale that would otherwise remain tight and afford protection. If painted with moisture present, as the scale loosens the paint likewise flakes off. Further, that incipient rust is a holder of moisture, causing deleterious action upon the steel.

(*b*) Heating the steel above 212° F. expands or explodes free semi-tenacious scale, drives off moisture within the scale and rust, as well as on the steel surface, leaving it in a warmed state conducive to adherence of paint.

(*c*) If semi-tenacious mill scale is lifted free and partially loosened scale and powdered rust are removed by hand wire-brushing, and if the surface is fully dehydrated and the surface and edges of the remaining tight mill scale fully painted, then an inactive and protected surface is provided.

Accepting this theory, the high temperature oxyacetylene flame provides a speedy economical performance.

Flat tips mounted on renewable steel hard-faced wearing skids, provide a row of close formation small brush-like flames which are guided across the surface at a forward speed of 10 to 20 linear feet per minute, and at a flame impingement angle of approximately 45 degrees. Widths of tips range from 2 to 12 inches in 2-inch accruements. These are used generally on flat surfaces. Round tips having hard-faced annular wearing rings are more efficient for cleaning of rivet heads, fittings, faying surfaces, corners and other projections inaccessible to the board flat tips. Rivet heads particularly carry a heavy scale.

As the flames progress along the surface, due to the differential expansion between the scale and the base metal, a variable amount of the mill scale is loosened and cracked off. This scale-lift may, in a measure, be also attributed to the conversion of the occluded moisture within and beneath the scale, to steam, with the result-

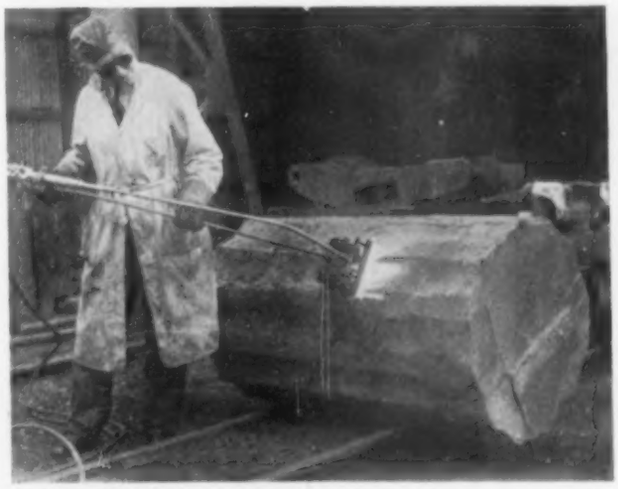


Fig. 3—Flame Descaling 31 Inch Round Ingot of 0.45 Per Cent Carbon, 1.25 Per Cent Nickel and 0.85 Per Cent Chrome with Flat Multi-Flamed Oxyacetylene Tips Mounted on Wheeled Carriage

Fig. 4—Flame Cleaning and Dehydrating Web Plate of Fabricated Structural Steel Girder in Fabricating Shop with Flat Multi-Flamed Oxyacetylene Tips Mounted on Hard-Faced Steel Skids

Fig. 5—Flame Cleaning and Dehydrating Clips and Rivet-Heads of Fabricated H Beam Column in Fabricating Shop with Round Multi-Flamed Tip Protected with Annular Hard-Faced Wearing Ring

ant explosion blowing the scale clear of the steel surface. The fully loosened scale flies in a shower of small flakes and minute particles which rapidly fall earthward. There is no dust hazard. A further amount is partially loosened to such degree that it is easily broken free by the light wire-brushing which immediately follows.

The flames remove surface impurities other than oil and grease which, as is customary, are removed (degreased) beforehand with mineral spirits, benzine or gasoline. Sufficient heat is imparted to the steel to raise its surface temperature to a point above 212° F. (but below 300° F.) driving off all moisture. However, the temperature is not raised sufficiently to create a condition injurious to the steel. Sufficient heat remains in the steel for an extended period to allow for painting before recondensation of moisture occurs on the surface of the steel.

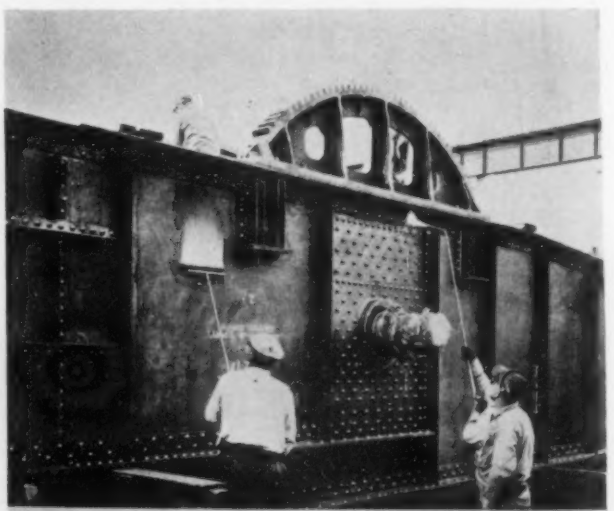
The process provides its own regulation and inspection. The operator quickly self-regulates his speed, in that if he moves too fast he will not lift sufficient scale, and if he moves too slowly, the surface will be slightly fused but not to an injurious extent. Therefore, he automatically accustoms himself to the proper speed for the removal of the maximum amount of the scale that will loosen. This amount is dependent upon the age of the steel members and to what extent they have been exposed to atmospheric change.

Steel, fresh from the rolling mill and with little or no weather exposure will seldom provide greater than a 10 to 15 per cent scale-lift, whereas aged steel, exposed for several months to atmospheric change, may provide for a scale-lift of 50 to 60 per cent.

That scale which will not lift either with the flame or the wire-brushing that follows, has passed on inspection proving it to be definitely tight scale which there is no point in removing, provided moisture is driven therefrom.

The oxyacetylene flame cleaning and dehydrating process provides a smooth natural surface. There is no graining of the steel and as the application may be made in the shop adjacent to other plant machinery or, being portable and flexible, made in the field, there are no steel handling and re-handling costs. The application is

Fig. 6—Flame Cleaning and Dehydrating Bascule Bridge Girder at Fabricating Shop Yard Using Flat Multi-Flame Tips on Web Plates and Round Multi-Flame Tip on Rivet-Heads and Irregular Surfaces



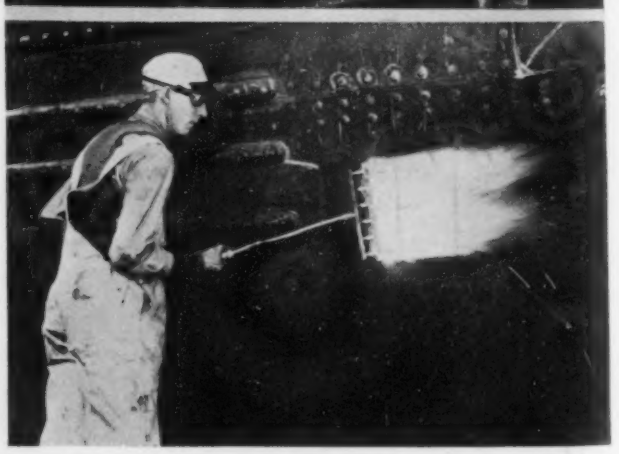


Fig. 7—Flame Cleaning the Outside of Hull Plates of All-Steel Light-Ship. Inside and Outside Hull-Plating, Bulkhead and Superstructure All Flame Cleaned Using Both Flat and Round Multi-Flamed Oxyacetylene Tips

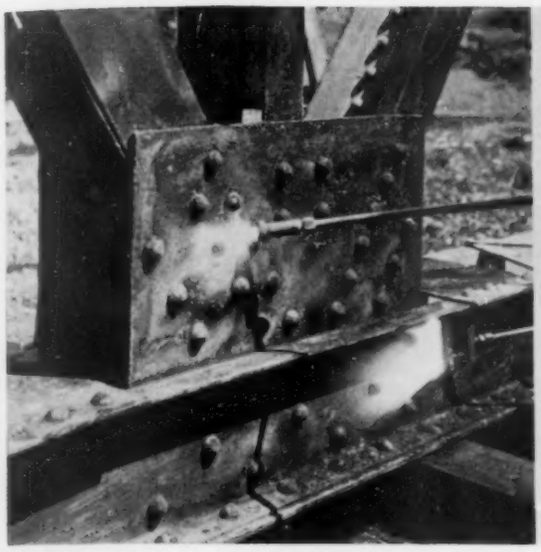


Fig. 8—Employing the Oxyacetylene Flame Cleaning and Dehydrating Process for Paint-Burning and Surface-Conditioning Old Painted Steel Bridge. Power Wire-Brushing Follows to Remove Loosened Rust and Scale and Cockled Paint

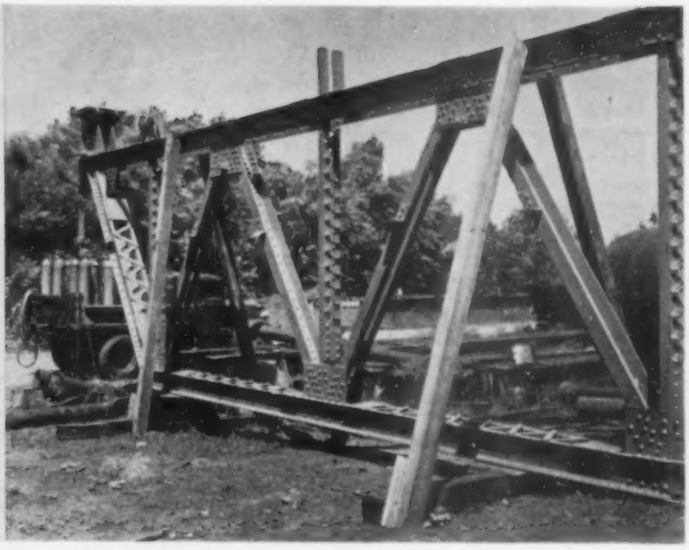


Fig. 9—Section of Reconditioned and Repainted Bridge Truss After Paint-Burning and Surface-Conditioning by the Flame Cleaning and Dehydrating Process. Note That This Steel, Fabricated in 1907, Again Appears Practically New

simple and safe, the health hazard angle being absent as there is very little dust. At the present time, this process is pronounced preferable by many engineering authorities in the fabrication field. It is felt by many to be superior to methods heretofore employed and on the strength of the process theory, a number of engineers and fabricators are making use of the process. Adherence to the recommended procedure is compulsory if satisfactory results are to be expected and, as a guide, specifications are available to users of the process as well as to those interested in entering such in their specifications. Cost estimating data are available based on tonnage and square footage for the particular classification of structure in which interest obtains, at any given time. As the square footage of surface per ton of steel will vary considerably due to the difference in structural shape, dimension and weight, a uniformly average cost per ton price for the process application is not readily obtainable.

PAINT-BURNING AND SURFACE-CONDITIONING

Recent experimentations with the oxyacetylene Flame Cleaning and Dehydrating Process for the paint-burning and surface-conditioning of old painted steel structures have met with most encouraging success. Early ineffectual methods of surface cleaning, or none whatever in most cases, followed by the resulting lift of loose mill scale and the eventual loss of paint, have resulted in many hundred thousand dollars expenditure on steel bridge surface maintenance. None of us need go far to view structures erected a few years past on which large areas are free of paint and are heavily atmospherically oxidized. Spot painting of these areas has not solved the problem to full satisfaction. A number of bridge engineers have arrived at the conclusion that the only satisfactory solution is the removal of the old paint either down to the base paint coat or, where possible, down to the steel, then properly condition the base surface and repaint. All loose mill scale and rust must be fully removed, the "open sores" thoroughly cleaned by power wire-brushing and carefully repainted.

Of more recent date is the recognition that dehydration of the surface, i. e., the driving therefrom of all moisture, is an essential. If moisture is present when repainting occurs, it will continue its destructive action so that within a year or two, and frequently less, inspection shows paint-lift and oxidation.

A superior quality method of paint-burning and surface-conditioning is provided by the oxyacetylene multiflame apparatus. Quick results are obtained by using the round tip with multiple orifices on rivet-heads and irregular surfaces, and the various width flat tips for plane surfaces. The flames are quickly passed over the scaled, rusted and painted surface with a progressive reciprocating action. Rust and scale are freed and the old paint is caused to loosen and cockle. Sufficient heat is imparted to drive off moisture and to remain until painted, but not enough to cause any injurious action to the structure. Power wire-brushing immediately follows removing the loosened rust, scale and cockled paint. A warmed, clean, dry surface is provided which is beneficial in obtaining a lasting paint job.

Where seven or eight coats of old paint are encountered, several passes of the flames with intermittent light hand wire-brushing can be employed. After the last flame passage power wire-brushing generally follows. Considerable success has been experienced using a multiflamed flexible head tip on which the heads can be spread apart or bunched together as desired to fit the dimension and shape of structure being cleaned. Where advisable, scrapers may be employed between and after flame passes. If deterioration has progressed to an unusual degree resulting in a measurable thickness of iron oxide, it is advisable to flake off such accumulation with scrapers beforehand.

DESIGN AND FABRICATION OF Welded Structures*

By C. E. LOOS† and F. H. DILL‡

I. INTRODUCTION

THE design and fabrication of framed structures involve problems which are not encountered in other classes of construction. The price at which fabricated structural steel is sold leaves little margin for refinements, and welding must show clear-cut economies to justify its use in this field. Advantages, such as freedom from leakage, large savings of material, or reduction of dead weight of moving parts, which result from the use of welding in the construction of tanks, pressure vessels, piping, machinery and rolling stock, are seldom realized in welded structural steel fabrication.

Framed structures, such as bridges, tier building frames, mill buildings, etc., are built of intersecting members which are connected to each other at the joints. The design of the members is governed primarily by the loads they must carry, but it is affected also by the method used for connecting them into the structure. *Welding is a method of connection.* Its use, therefore, requires careful analysis of joint detail to determine its effect on the members themselves.

Before entering into the subject of structural welding certain limitations of materials and processes should be observed. The principal material used for framed structures is open-hearth steel, such as A. S. T. M. specification A7 or A10, in the form of "structural plates and shapes." This steel ordinarily has 0.15 to 0.28 per cent carbon content and it can be safely welded if the following restrictions are observed:

1. The carbon content must be below 0.32 per cent.
2. Sufficient heat must be applied in welding to offset the chilling effect of the base metal.

Low-alloy structural steels are not economical for welded framed structures unless the direct reduction in weight, which results from their use, engenders additional savings elsewhere in the structure which will lower its total cost. Many kinds of low-alloy steel are now available for structural fabrication, but their weldabilities cannot be broadly predicted beyond the statement that their carbon content should be low. Preheating is sometimes essential for the successful welding of these steels, but it is a slow operation at best, and it may cause troublesome warpage of the structure.

Practically all structural welding is done by the shielded metal arc process, using heavily coated electrodes (classified in Fig. 1) which will deposit weld metal having an ultimate strength of more than 60,000 psi and an elongation in 2 inches of at least 17 per cent. Most of the electrodes now used greatly surpass this strength and are thus adequate for the welding of the low-alloy structural steels as well as the usual grades of structural material. Other welding processes, such as the automatic metal arc, carbon arc and Unionmelt processes, are occasionally used for structural welding and designers should be alert to realize their advantages and economies wherever possible.

The members of riveted and bolted framed structures have almost always been connected with lap joints and, because this type of joint readily absorbs the unavoidable variations in the size of material, it is still widely used for joints of welded framed structures. T-joints of various sorts are, of course, inevitable in structures whose members lie in different planes and at various angles with each other. Butt joints are novel in the structural field and have many characteristics which warrant their use. They are particularly desirable where connections must resist high stresses or be extremely compact. Various other types of joints and welds have occasional uses in structural fabrication, but their application is usually special and rather limited.

II. DESIGN

The direct economic advantage of welding the joints of a framed structure lies in the connecting of members without the use of supplementary connection material. The indirect advantage is in the saving of material because of rigid end connections, the elimination of holes in tension parts or the more efficient distribution of material. In framed structures the indirect savings are usually greater than the direct economy in the joints themselves, but their attainment must be balanced against the increases in cost of fabrication which they may involve.

The inherent rigidity of welds is extremely important

NEMA SPECIFICATION		COATING	AWS-ASTM SPECIFICATION A233 T7		
CLASS	DESCRIPTION		GRADE	TENSILE STRENGTH *	ELONGATION *
A	Bare	No coating; except that the "sulcoat skin" is not removed.	40 30	47 000 47 000	3 5
B	Thinly coated	A thin coating designed primarily for arc stabilization	20	55 000	7
C	Heavily coated	A heavy coating designed to stabilize the arc and protect the molten weld metal			
		1. Gas-shielded - "All position" Organic coating Reverse polarity, DC only	10	60 000	20
		2. Semi-slag shielded - Universal" High titania coating Straight or Rev. Polarity DC or AC	15 or 10	60 000 60 000	17 20
		3. Slag-shielded - "Down-hand" Mineral coating DC or AC welding	10	60 000	20
D (TS	High tensile over 75000)	Heavily coated, usually of the gas shielded type with alloying elements in the coating or alloy steel wire with coating suited to electrode use	4 or 2	75 000 80 000	15 15

* Physical properties for non-stress-relieved all-weld tensile test
Tensile Strength, min., lb. per sq. in.; Elongation, min., % in 2"

Fig. 1—Electrode Classifications

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.
† Carnegie Illinois Steel Corp.
‡ American Bridge Co., Pittsburgh, Pa.

ALLOWABLE WORKING STRESSES FOR WELDS
POUNDS PER SQUARE INCH.

AWS CODE FOR FUSION WELDING IN BUILDING CONSTRUCTION

GRADE OF ELECTRODE (AWS ASTM A 233-37T	TYPE OF STRESS ON WELD THROAT SHEAR *	TENSION	COMPRESSION
2-4-10-15	13 600	15 600	18 000
20-30-40	11 300	13 000	18 000

* Any stress in fillet welds shall be considered as shearing stress

AWS SPECIFICATIONS FOR WELDED BRIDGES

GRADE OF ELECTRODE	TYPE OF WELD	TYPE OF STRESS	KIND OF STRESS IN MEMBER FLUCTUATING-F	STATIC-S
2-4-10-15	BUTT	TENSION COMPRESSION	13 500	16 000
		SHEAR	9 000	12 000
	FILLET	TENSION COMPRESSION SHEAR	7 200	9 600

▲ Weld Throat Area, $A = \frac{\text{Max} - \frac{1}{2}\text{Min}}{F}$ but not less than $\frac{\text{Max}}{S}$

Where Max indicates the numerically greater stress
Min smaller
F & S are the unit stresses tabulated above

Fig. 2—Allowable Working Stresses for Welds

in the design of welded joints. The strain, both elastic and plastic, across any weld at ordinary working stresses is practically nil because the stress length is short. It is obvious, therefore, that the connecting welds of a joint cannot yield enough to relieve stress applied to it. In riveted connections there is almost always some yielding, either through slip in the rivets or distortion of supplementary connecting material, which effects readjustment of stresses or relief of restraint. Since such action cannot occur in welded structures, unless special provision is made for it, engineers who are steeped in the traditions of designing riveted structures must recognize the rigidity which is an inseparable characteristic of welded joints.

Fatigue, the effect of repeated applications of load, is a subject much discussed in connection with the design of welded structures. Its importance arises largely from the fact that the rigidity of welds engenders stress concentrations whereas the slip and yielding, which occur in riveted joints, tend to dissipate them. The effects of fluctuating stress were recognized in some of the earliest specifications for steel structures, and the salient facts concerning fatigue which are important in structural design can be summarized as follows: The severity of fatigue depends on the number of applications of stress, the manner in which the stress varies and the magnitude of localized stresses. The nature and number of stress applications are considered in establishing the working stresses for structures subject to repeated application of load. (One of the best discussions of these stresses is that in the AMERICAN WELDING SOCIETY'S "Specifications for Welded Highway and Railway Bridges," paragraphs 202 to 206 and Apendix A.) The magnitude of the localized stresses in a joint under a particular loading is determined largely by its "smoothness" and the consequent continuity of its stress path. Thus welded butt joints, which have no internal discontinuities and fairly smooth surfaces, are superior to fillet-welded joints which are inherently discontinuous. The attainment of ideal joints is, however, limited by practical and economic considerations, and properly designed fillet-welded joints can be perfectly satisfactory for structures which support dynamic loads.

The effects of impact and repeated loading are usually interrelated in the design of structures, but they must not be confused with each other. Increased strength or mass is generally sufficient to withstand impact loading, but resistance to repeated loading is attained by the elimination of stress concentrations, sometimes by eliminating material rather than by adding it. For example, quarter-round fillets or butt welds having reinforcements of 10 to 20 per cent of the throat thickness have lower fatigue resistance than welds with less reinforcement and their use should never be specified. Good root fusion is much more important for welds subject to repeated loading.

Practically all specifications governing structural welding are intended to supplement an applicable specification or building code which governs the selection of loads and the general design of the structure and its

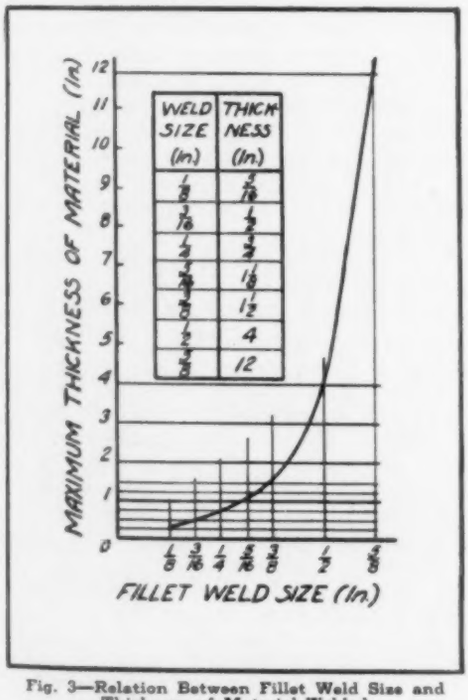


Fig. 3—Relation Between Fillet Weld Size and Thickness of Material Welded

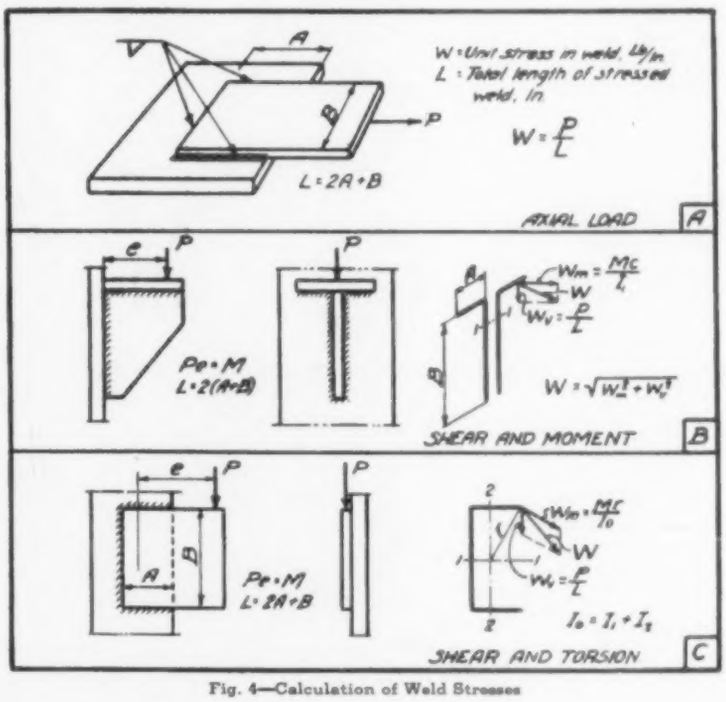


Fig. 4—Calculation of Weld Stresses

members. The welding specifications establish the unit stresses for welds, and for base metal when necessary, and prescribe the workmanship and procedures which are essential to the successful accomplishment of the required welding. The AMERICAN WELDING SOCIETY'S two specifications which govern welding in structural fabrication are: "Code for Fusion Welding and Gas Cutting in Building Construction;" "Specifications for Welded Railway and Highway Bridges." The first of these is written to govern the application of welding to the construction of buildings and other structures which support static loads, while the specification for bridges is applicable to structures which support dynamic loads.

The allowable working stresses for bare wire welds were firmly established by the investigation of the Structural Steel Welding Committee of the American Bureau of Welding which was reported in 1931. The subsequent development and commercial use of heavily coated electrodes, which deposit ductile weld metal having an ultimate strength of at least 60,000 psi, have, however, justified the use of higher stresses for shielded metal arc welds. Those now permitted by the AMERICAN WELDING SOCIETY'S two structural welding specifications are shown in Fig. 2. The stresses allowed by the bridge specifications have been established, as described in their Appendix A, largely from the results of repeated loading tests of welded joints. These bridge specifications also restrict the working stresses allowed in members subject to reversal of stress or connected by fillet welds.

The size of fillet welds is ordinarily selected with regard to the inherent economy of small welds, the necessity of making connections in small space and the limitation of welding technique. Practical evaluation of these factors has established the $^{5}/_{16}$-inch fillet as the common size for structural welding. This size of fillet can be made in a single pass, but larger fillets generally require two or more passes and their cost increases almost in proportion to the square of their size. Larger welds are, of course, unavoidable when the connection space is limited and they must be used also to offset the chilling effect and rigidity encountered in welding thick material. The chart in Fig. 3 shows the minimum fillet-weld sizes which practical experience has proved satisfactory for welding various thicknesses of material. (The greatest thickness of material which a fillet weld connects determines the minimum size of weld that may be used.)

Stresses in welded joints are calculated by the ordinary methods of structural mechanics, as illustrated in Fig. 4. The size of welds stressed by axial or symmetrical loading is determined by computing the stress area from the known loading and the allowable unit stress. If welds are stressed by eccentric or unsymmetrical loading, their size and distribution must be assumed and the maximum resultant unit stress calculated. This resultant stress must not exceed that allowed for the welds used and it is calculated from the unit stress components obtained by separating the applied load into a direct load and a bending or torsional force. The direct stress component is simply the quotient of the direct stress divided by the weld area. The stress component for a bending force is found from the flexure formula Mc/I, using for I the moment of inertia of the connecting welds about the gravity axis which is normal to the plane of bending. If the eccentric force is torsional in its effect, the same formula is used, but I must be taken as the polar moment of inertia of the connecting welds.

Since the width of a fillet-weld throat is small, its stress may be considered as a "line of force" and only its length and position are then involved in stress calculations. Unit stresses are, of course, determined in pounds per lineal inch and this is a convenient unit since it bears direct relation to the weld size. This simplification of calculation is helpful where complicated joints must be analyzed, and it is generally used.

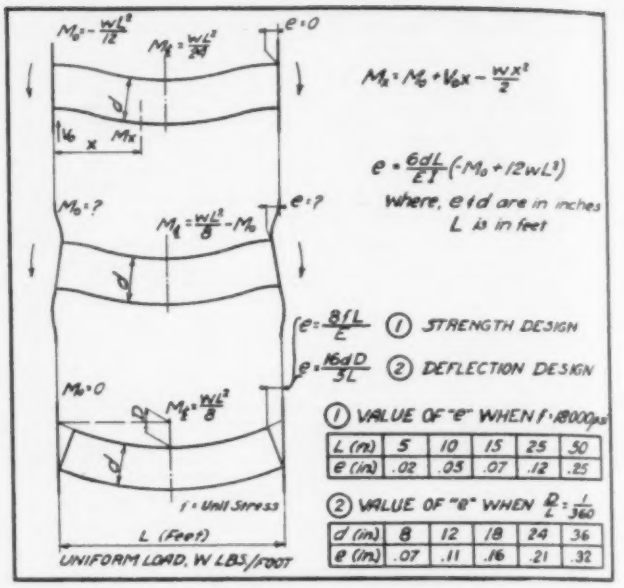

$M_0 = -\frac{WL^2}{12}$
$M_1 = \frac{WL^2}{24}$
e = 0
$M_x = M_0 + V_0 x - \frac{Wx^2}{2}$
$\frac{1}{16} \times M_x$
$e = \frac{6dL}{ET}(-M_0 + 12wL^2)$
Where, e & d are in inches
L is in feet
$M_0 = ?$
$M_1 = \frac{WL^2}{8} - M_0$
e = ?
$e = \frac{8fL}{E}$ (1) STRENGTH DESIGN
$e = \frac{16dD}{3L}$ (2) DEFLECTION DESIGN
$M_0 = 0$
$M_1 = \frac{WL^2}{8}$
(1) VALUE OF "e" WHEN f = 18000 psi
L (in) | 5 | 10 | 15 | 25 | 50
e (in) | .02 | .05 | .07 | .12 | .25
f = Unit Stress
(2) VALUE OF "e" WHEN $\frac{D}{L} = \frac{1}{360}$
L (Feet)
d (in) | 8 | 12 | 18 | 24 | 36
e (in) | .07 | .11 | .16 | .21 | .32
UNIFORM LOAD, W LBS./FOOT

Fig. 5—Beam End Deflections

The above principles are the basis of calculation for the various formulas, tables and diagrams which have been developed and published to aid the engineer in designing and calculating the strength of welded joints. The data and charts presented in Mr. H. M. Priest's paper, "The Practical Design of Welded Steel Structures,"* are excellent examples of the applications of these principles and should be carefully studied by engineers designing welded structures.

The determination of the loads to be used in designing welded joints is, unfortunately, not as simple as the calculation of their strength. Years of use of riveted connections have developed standards and empirical rules which supplement, or even supplant, the nominal requirements of the calculated stresses in the design of members and their connections. For example, standard beam connections are assumed to carry only shearing load and cause no restraint of the beam end. Such rules exist because experience with riveted structures justifies them, but they are not always applicable to welded joints. Some of them would produce uneconomical details and others would result in unsafe connections. Until experience with welded construction establishes its own rules, welded joints must be thoroughly analyzed. The rigidity of welds and the effect of welded joints on the stresses in the connected members must be carefully considered.

Columns are essential members of almost all building frames, and they must be fastened to their foundations and have their separate sections joined together. The design of the base connections is governed by the external foundation reactions and is relatively simple. The design of the connections joining the separate sections of a column is more indeterminate. These joints must transmit axial compressive forces and the abutting ends are commonly faced to carry this stress by direct bearing. There are also bending and shearing forces in any column, which usually are not predicted by its design, but which require a splice that will hold the abutting

* AMERICAN WELDING SOCIETY JOURNAL, August 1933.

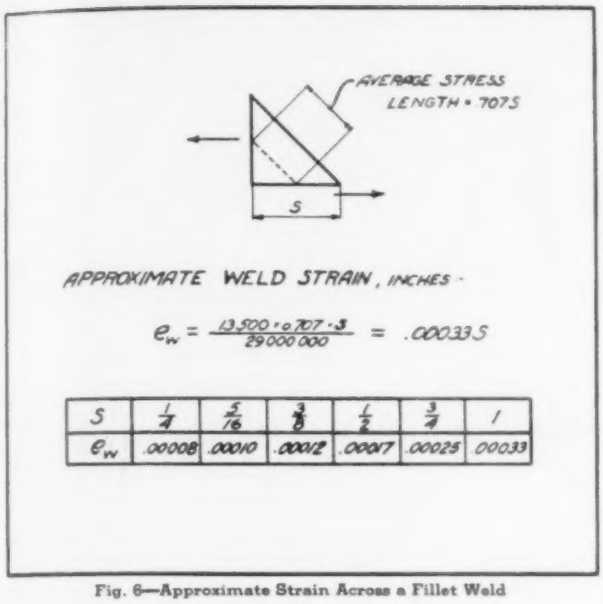

AVERAGE STRESS
LENGTH = .707S
S
APPROXIMATE WELD STRAIN, INCHES
$e_w = \frac{13,500 \cdot .707 \cdot S}{29,000,000} = .00033S$
S | 1/4 | 5/16 | 3/8 | 1/2 | 3/4 | 1
e_w | .00008 | .00010 | .00012 | .00017 | .00025 | .00033

Fig. 6—Approximate Strain Across a Fillet Weld

sections together and in alignment. The splices commonly used are the interposed plate type or a detail made to simulate the splices used for riveted joints, but arranged to avoid holes in main material. The welding is usually designed to make the splice as strong as a corresponding standard riveted splice or to develop 25 per cent of the minimum bending strength of the connected members. If the column is loaded so that there is calculated moment or shear at its splices, these forces should prevail over the empirical rules in the splice design.

The connection of beams to columns or other supporting members is complicated by the fact that the detail of the connection affects the forces involved. The problem of designing satisfactory beam end connections is primarily economic rather than technical, but attempts to gain extreme economy have often disregarded essential technical requirements of such joints.

A general consideration of the problem shows three degrees of end restraint:

1. Complete restraint—the fixed end beam.
2. Partial restraint—the ordinary practical condition.
3. No restraint—the simply supported beam.

Figure 5 illustrates these conditions and their effect on the beam's stresses and deflections. The amount of movement of the top flange at the end of a simply supported beam should be particularly noted because any restraint of this movement will induce forces which the connection must withstand. This movement is roughly one thousand times the strain across a weld at ordinary working stress (approximately evaluated in Fig. 6), and it is apparent that any weld used to connect a beam directly to its support is a rigid connection. Any relief of the beam's end restraint must come from the supporting member—it cannot come from the welds. The basic principle of beam connections is, therefore: *Connections which have any weld above the bottom of the beam must have welds strong enough to carry the full restraining moment offered by the supporting structure.*

What is the magnitude of the restraining moment? This question has always vexed the designers of framed structures whose rigidity is dependent on the stiffness of their joints. There are many methods of analysis for approximate or exact determination of the joint moments in framed structures, but there are also many structures which do not merit such study. Practically, the restraint developed by a rigid connection can be classified under one of the following conditions, which are illustrated in Fig. 7:

1. Major restraint, or nearly complete fixity, when the beam is light and the supporting structure is stiff.
2. Complete continuity, when similar beams are connected to opposite sides of a non-rigid supporting member.
3. Minor restraint, when the beam is stiff and the supporting structure is not.

If any of these conditions can be clearly identified in the structure being planned, the welds of the joint may safely be designed for the corresponding end moment, but if the degree of restraint is doubtful, the welds should be designed to develop the bending strength of the beam.

The economy of rigid connections results from the reduction of the moment at the center of the beam by an amount equal to the restraining end moment. This is usually gained at the expense of a large amount of welding, most of which must be done in the field, and also some reinforcement of the columns to make them capable of properly distributing the reactions from the rigid beam connections. Occasionally the reinforcement of columns can be economically avoided by using larger sections, but in any case the use of rigid connections requires joints which fit neatly and accurately and provide adequate space for the connecting welds. Rigid connections are not economical unless the savings they induce are greater than the increase of fabricating cost which they entail.

Seated connections for beams have negligible restraint of the end rotation, but their use is limited in two ways. Unstiffened seats should not be used for reactions greater than 35,000 pounds, nor for beams over 21 inches in depth. Stiffened seats can support practically unlimited reactions, but restrictions of available space often prohibit their use. Various tests and investigations have adequately demonstrated the strength of these connections and also have shown that the ordinary methods of mechanics are accurate for their design. It is essential, however, that the common practice of welding the upper part of a seated beam to the supporting member, for lateral support only, be avoided. Such welds will break as soon as the beam deflects and are then useless for their

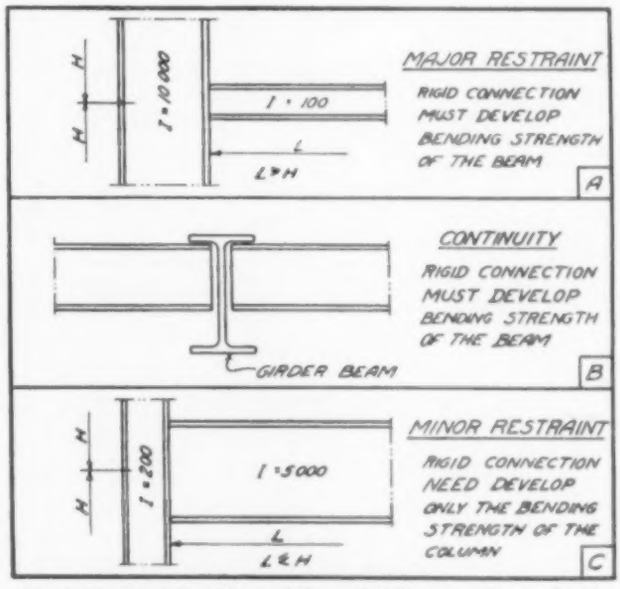


Fig. 7—Practical Conditions of Beam End Restraint Due to Rigid Connections

intended purpose. If the upper part of a seated beam needs lateral support, a detail which will accomplish this without interfering with the beam's deflection must be used.

Various types of beam connections, designed to attain the yielding which is essential for the relief of end restraint, have been proposed, tested and occasionally used. The standard connection angles used for riveted beam end connections have considerable flexibility in their outstanding legs, and they distort under load so that there is no appreciable restraint of the beam end. Welded connections have been made with angles arranged to simulate this action, but tests have shown such joints to be unreliable. The prying action, which is exerted against the root of the welds by the necessary distortion of the angles, is a force against which fillet welds have very low resistance. Designs which entail super-elastic strain in the structural members and their welds are of very questionable value because they are contrary to the requirements of ordinary specifications and are generally justified only by an "it hasn't failed yet" philosophy and reasoning.

The savings made possible by welded construction of plate girders can be summarized as follows:

1. The elimination of holes from the tension flange and from the web allows smaller gross sections to be used.
2. Flange material is concentrated farther from the neutral axis so that the effective depth is greater than for a similar riveted girder.
3. The connected leg of stiffener angles is made unnecessary by the use of flat plates for stiffeners and the crimping of stiffeners or the use of filler plates to fit them over the leg of flange angles is avoided.

The gain possible under Item 1 is lost when the specifications permit riveted girders to be proportioned for their gross section and it also is lost in a welded girder having an unbraced top flange, if the two flanges are made alike. Welding does not materially affect the design of compression flanges of girders. The other two items are primary advantages of welded construction which are ordinarily realized. Figure 8 compares the make-up of riveted and welded girders and shows that the web of a welded girder must be accurately trimmed. There is no space to accommodate minor irregularities

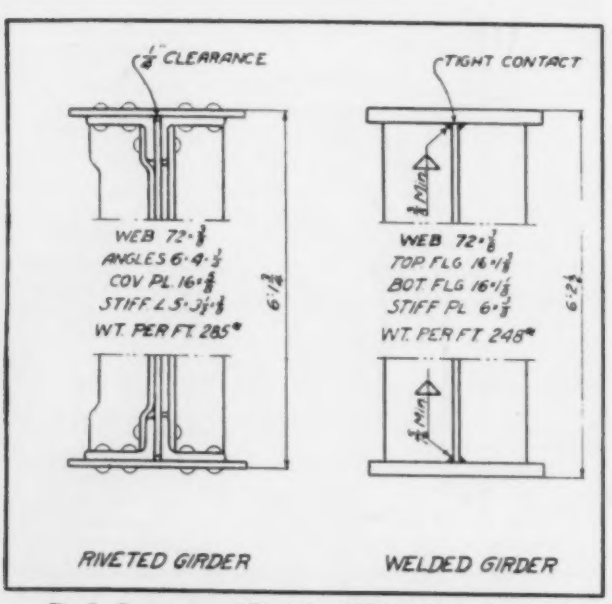


Fig. 8—Comparison of Riveted and Welded Girder Sections

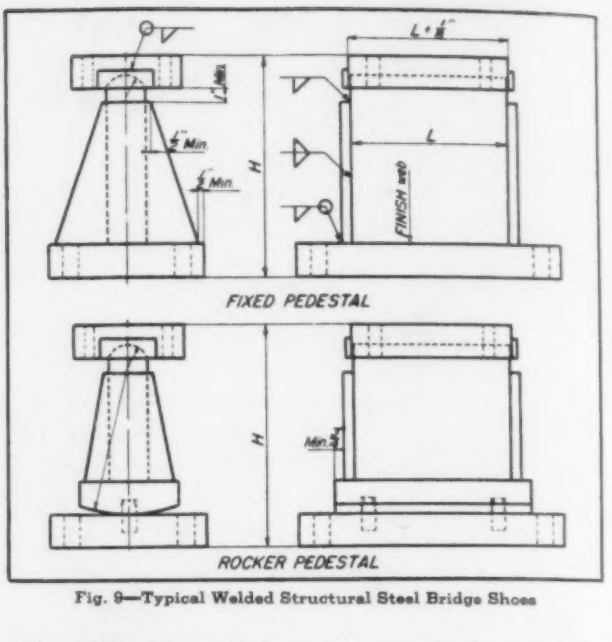


Fig. 9—Typical Welded Structural Steel Bridge Shoes

of the plate edge and any camber required must be cut into the web. Camber cannot be attained as simply as it is in riveted girders where minor changes of rivet spacing are sufficient to attain normal amounts of camber.

Some published discussion of welded girder design have stressed the economy attainable by reducing the flange section where diminished bending forces permit. In such studies the cost of making the necessary flange plate splices is often neglected, although it may amount to a large portion of the possible saving. For example, an investigation of a 40-foot girder carrying a building column showed that the cost of four splices necessary to reduce an 18 x $2^1/_2$-inch flange to an 18 x $1^3/_8$-inch section was over 60 per cent of the cost of the material which could be saved. The use of several different sizes of material for stiffeners on a single girder also is an example of close design which is not always commercially justifiable. Extreme refinement of design is usually unwarranted unless duplication multiplies the savings gained, so that they are greater than the increases in fabricating cost which usually arise.

The use of welding for truss construction produces lighter trusses than can be built by riveting and they are generally neater in detail. The reduction of weight is accomplished principally through the elimination of holes in tension members and the use of less connecting material at the joints. These economies, however, practically limit the use of welding to the fabrication of trusses which can be shop assembled, either completely or in large sections.

The chief problem of truss design is to choose material which will fit together with a minimum of supplementary material and still provide effective space for the necessary welds. The use of butt-welded joints requires careful preparation of the members because they must fit accurately, if the welds are to be properly made. Both length and alignment of material must be accurate to one-sixteenth of an inch. Misalignment may seriously reduce the strength of the joint and inaccuracies in length will make the welding of the joint either difficult or expensive. Lap joints provide space to absorb many inaccuracies of the truss material and they generally permit a distribution of the connecting welds which will avoid localization of the stress in the joint. It is futile, however, to expect the ordinary run of structural material to fit neatly and accurately together with-

Fig. 10—Welded Steel Bridge Shoes

out any preparation or supplementary connecting material.

Welded roof trusses are often more economical than riveted trusses, if there is a sufficient number of them to justify the construction of a jig for their assembly. The reduction of gross section, through the elimination of holes, may save as much as 30 per cent of the weight of tension members and the partial elimination of gusset plates creates additional savings, so that an overall saving of 10 to 20 per cent of the weight of a riveted truss is attainable. Large T-sections are often used for welded roof truss construction and the use of double angle sections for other primary members permits simple connections with little preparation of material and few gusset plates. In trusses of this type small joint eccentricities, knowingly used, are preferable to crowded connections which leave insufficient space for welding. Gusset plates must be used, however, to prevent the occurrence of large eccentricities.

Field splices are usually necessary for joining the shop-assembled sections of roof trusses and if the truss can be assembled on the ground and erected as a unit, there is no need for bolts in these joints. The splices of a truss, which is to be erected in sections, however, must provide for the use of bolts and pins to hold the joints together until they are welded.

Wide flange beam and column sections are commonly used for the members of bridge trusses which can be wholly or partly shop assembled, but the variations in

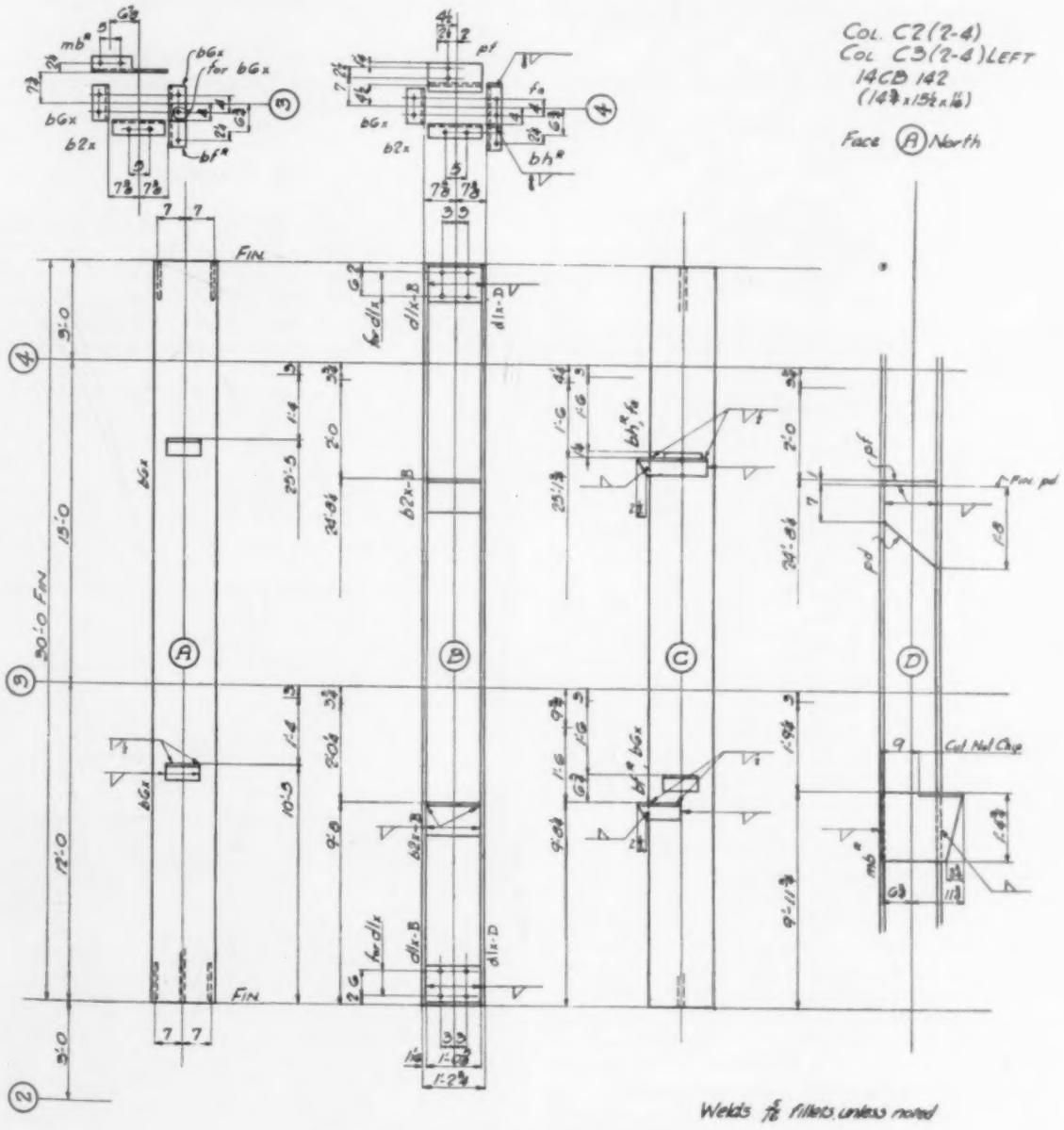


Fig. 11—Shop Drawing for a Typical Structural Member

their dimensions make them difficult to use in welded construction. The substitution of built-up sections often results in a loss of economy and appearance. If fillers are used to correct the variations in dimensions of the wide flange sections, the amount and cost of welding will be increased. If holes for bolts to draw the joints tight are used, little economy in favor of welding remains. When any holes are used, it is generally more economical to bolt or rivet the joint entirely than to complete its connection by welding.

As an example of the difficulty of using wide flange sections for the members of welded trusses the following experience may be cited. The design for several highway bridge trusses specified the use of various sizes and weights of wide flange sections, which all had the same nominal depth. As a result of mill variations, however, the actual depths of members meeting at any joint differed by about $^1/_4$ inch and in several cases by $^1/_2$ inch. Gusset plates were hard to fit to the members and some of them were warped enough to cause trouble in welding the floor beams to them. Obviously, the depth of wide flange sections, used for the construction of welded bridge trusses, must be accurately controlled, at least at the joints, and the cost of such trusses will be increased by the additional work required.

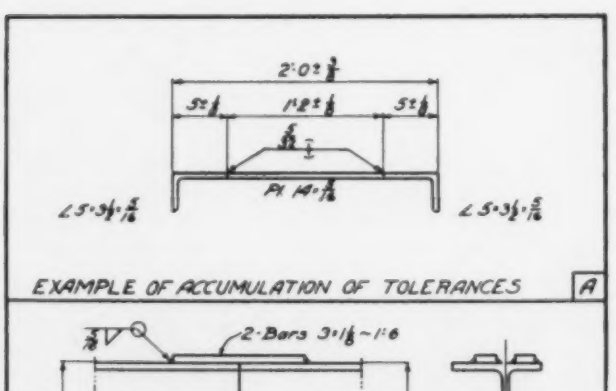


Fig. 12—Effects of Variations in Dimensions of Material

The connections of bridge floor beams, stringers and bracing are similar to those of beams used for building construction, except that they are subjected to repeated dynamic loading. The analysis of their design is the same as for statically loaded connections of buildings, but the details and working stresses which may be used are more closely restricted.

The shoes or pedestals used to support bridge trusses can be made very neatly and economically with welded rolled steel instead of the steel castings which have been commonly used in the past. The detail shown in Figs. 9 and 10 has been found very simple and practical for moderate sizes of shoes. The rounded top of the web eliminates the usual forged pin and the thickness of this slab makes stiffeners between the end plates unnecessary. The sole plate can be connected to the shoe to resist uplift if necessary. Designers of welded rolled steel shoes must not copy the details which have been used for cast shoes. The elimination of unnecessary stiffeners makes the welds more accessible and also reduces the total amount of welding required. Avoidance of unnecessary and complicated machining operations is most important, if an economical shoe is desired.

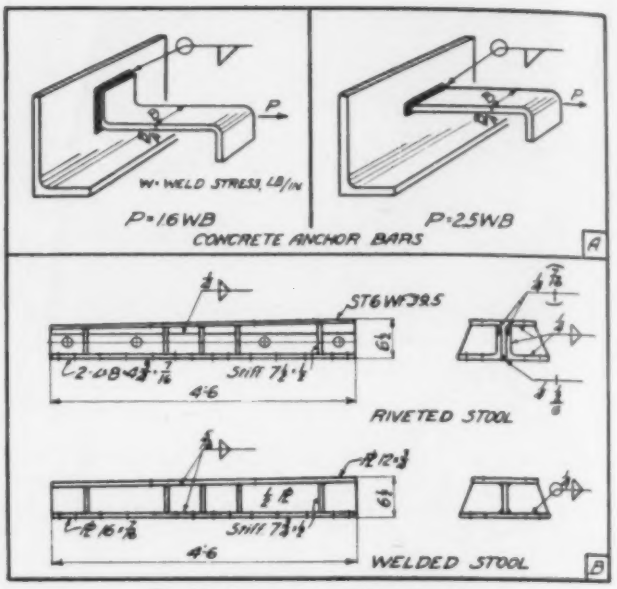


Fig. 13—Comparison of Joint Details

III. DRAWINGS

The design drawings for a welded structure must convey all the information ordinarily required for making estimates and working drawings and they must also clearly indicate the type of connections required. For example, they must show whether beam connections are to be rigid or flexible and whether butt or lap joints are to be used.

The detail or shop drawings must show the size, shape, length and location of all the welds required in the shop fabrication of the structural members and their assemblies. Separate drawings must be made to show the details of the field connections of a welded structure because they are not directly apparent from the general erection plan and the assembly of the joints. Ordinarily

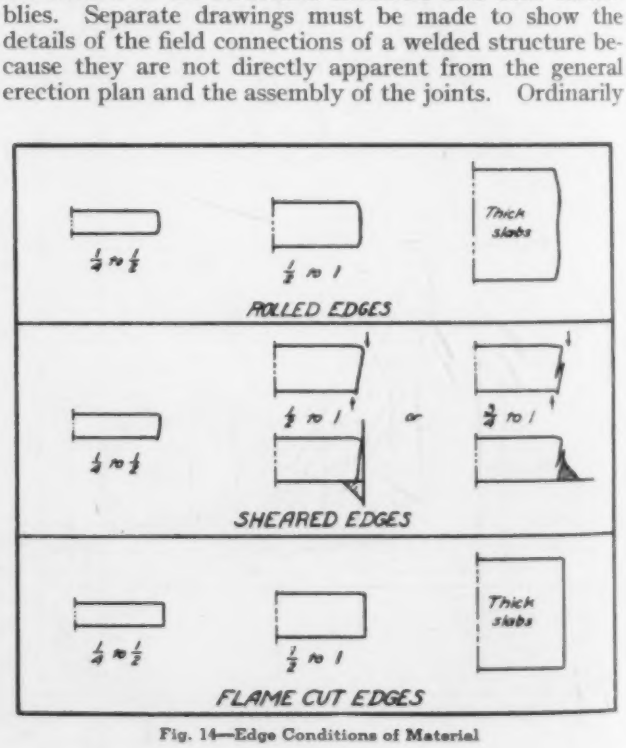


Fig. 14—Edge Conditions of Material

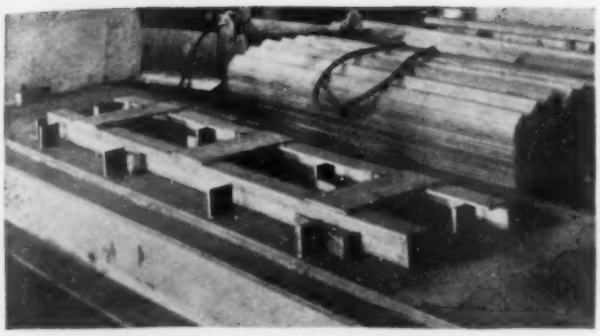


Fig. 15—Typical Jig for Simple Assemblies

these drawings are made as general details of each joint and are used in ordering material and in the preparation of the shop drawings, as well as for their ultimate service in the erection of the structure.

All information regarding the details and location of welds should be given by means of the AMERICAN WELDING SOCIETY'S Standard Symbols for Welds. The universal use of these symbols will insure easy reading of the drawings and will aid considerably in reducing the mistakes and misunderstanding which inevitably occur when welds are not systematically detailed. Figure 11 illustrates the application of the AMERICAN WELDING SOCIETY'S symbols to a shop drawing for a typical structural member.

IV. SELECTION AND PREPARATION OF MATERIAL

Selection and preparation of material are as important as stress design in the successful use of welded construction. They control the detail of joints and the economy of welding. Dimensional tolerances of members, joint fit-up and erection clearances are all affected by the choice and use of material.

Rolled steel is a very uniform material in many respects, but the tolerances required in the production of structural shapes and plates must be considered by the designer. The standard structural handbooks list these tolerances in detail, but a few of the more important can be summarized as follows:

1. A variation of minus $1/8$ inch to plus $3/16$ inch in the depth of beams, and of minus $1/8$ to plus $1/4$ in the width of beam flanges, legs of large angles and Universal Mill plates, can be expected.

2. The lengths of beams and channels which are not trimmed to exact length in the fabricating shop may vary plus or minus $3/8$ to $1/2$ inch for lengths up to 30 feet. The plus tolerance will be greater for lengths over 30 feet.

Fig. 16—Jig for Accurate Quantity Production

3. Plates over 36 inches wide, those which are commonly used for girder webs, may have a camber of $1/8$ inch for each 5 feet of length and their width may vary from minus $1/4$ inch to plus $3/4$ inch, or even more for extremely large plates.

The effect of these variations is serious when the design permits their accumulation or where they make the use of thin fillers necessary. The lap joints and splices which are characteristic of riveted work automatically prevent the accumulation of overrun of material and the established rules of the drawing room provide proper clearances for it. The necessity for butting material in many types of joints which are commonly used for welded structures requires special attention to variations in dimensions. In some cases the total of the standard tolerances of the component shapes may exceed the tolerance permissible for the dimensions of the finished member, as illustrated in Fig. 12-*A*.

The use of wide-flanged beams in riveted construction has always required the use of thin fillers or shims at points where their depth was fitted between fixed connection surfaces, such as the gusset plates of a truss or

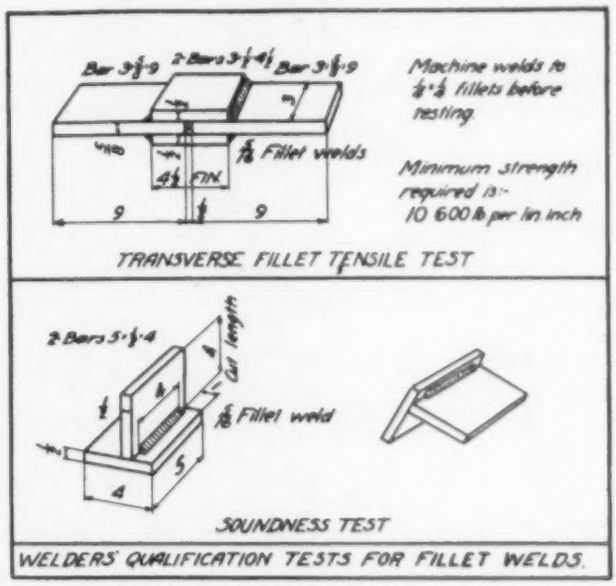


Fig. 17—Detail of Welders' Qualification Test

the headpieces of a wind moment connection on a column. Such fillers are not practical for welded joints. At best they require disproportionate amounts of welding to develop the strength of the joint, as shown by Fig. 12-*B*, and in other cases it may be impossible to transmit the joint forces properly through this intervening material.

Details which have been developed for riveted construction, particularly those of joints whose design is not governed by stress calculations, should not be promiscously applied in welded construction. Lap joints and double thicknesses of material are frequently used in curbs, expansion dams, railings and fascias with little thought of economy of material in welding.

A simple example is the connection of concrete anchors to curbs or expansion dams, shown in Fig. 13-*A*. The Z-bent anchor is copied from the detail used when the bars are attached with rivets countersunk in the curb or dam face. It requires twice as much bending and welding as the L-shaped bar, but its connection will develop only about one-half of its strength. The connection of the L-shaped bar, however, will develop the full strength of the bar because it is symmetrically loaded.

One of the most extravagant uses of welding is the filling and sealing of the joints of riveted members. Gaps to be filled vary considerably from the dimensions the designer expects and often the amount of welding required is sufficient to make a more efficient all-welded member.

Figure 13-*B* illustrates a beam stool made by riveting a T-section between a pair of angles with welding used to seal the joints. The resulting web is disproportionately thick; about one-half of it carries no stress, and the rivets are ineffective because the rigid welds will carry the load. The welded design shown requires but little more welding than the riveted stool and does not involve as expensive material. It uses the material more efficiently and it is neater in detail for future maintenance.

The condition of the edges which form fusion planes of fillet welds is another item frequently overlooked in designing welded structures. The rolled edges of steel plates and shapes are often rounded or not square with the surfaces of the material, and thus may be detrimental to good joint fit-up, especially in thick material. The "skirt phenomenon," which is commonly seen on the slugs from punched holes, often occurs in shearing thick plates and leaves a false surface which should be removed prior to welding. The shearing of thick plates also deforms their edges and causes poor joint fit-up. Edges which have been flame-cut with a mechanically guided torch are both square and true and where rolled or sheared edges are unacceptable this process provides a very economical and satisfactory edge preparation. Where its use is essential, it should be specified. Figure 14 illustrates these edge conditions and some of the difficulties they cause.

V. ASSEMBLY

The preparation of material for welded structures prior to shop assembly is not as elaborate as that required for riveted structures. Holes in main material are avoided as much as possible, so that it will require only straightening, squaring and trimming. Holes which are necessary for assembling and erecting the structure are arranged to be in the detail parts wherever possible, and the detail pieces are punched and cut to shape as for riveted work. After the material reaches the fitting skids the fitter must make up for the lack of previous preparation by laying out all the joints and connections before he can assemble the pieces. In doing this he has no working points within the piece, but must make most of his measurements from the edges of the material and make adjustments for variations of its dimensions.

The lack of holes in the main material is apparent as soon as assembly begins. The fitter must attach lugs and use clamps and wedges and even pulling devices to bring stubborn material to line and hold it until it can be tack welded in place. If there are several pieces alike, jigs can be built to establish identical dimensions for each piece assembled in them and also provide the backing necessary to force the material to line. A duplication of five to ten pieces is enough to justify the construction of a simple jig for large pieces, such as girders or trusses. Smaller and simpler parts, of course, may have to be duplicated fifty or a hundred times before jigs become economical for them. Other assemblies, such as those which demand extreme accuracy of finished dimensions without subsequent machining, can hardly be built without jigs. Figure 15 shows a very simple type of jig for truss-like assemblies, and Fig. 16 illustrates a more elaborate type for the accurate production of a large number of pieces.

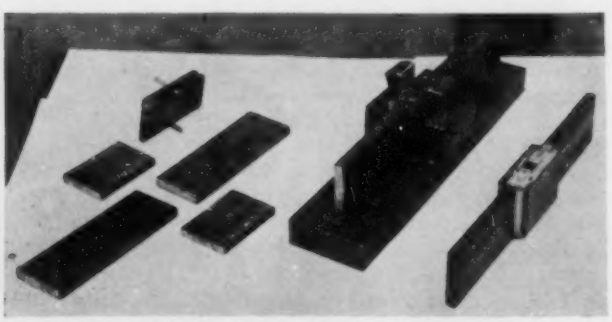


Fig. 18—Assembly of Qualification Test Specimen

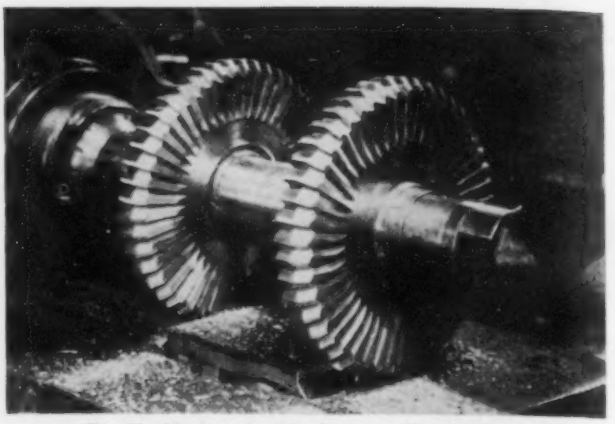


Fig. 19—Machining of Qualification Test Specimen

During assembly the fitter must make proper allowance for the shrinkage which will occur when the piece is welded. Experience and good judgment are the prime factors in making such allowance because there are no dependable rules for predicting the amount likely to occur. Designers can assist in avoiding troublesome effects of shrinkage, if they recognize its inevitability and choose details which allow some tolerance in the size of the members. The detailer must provide sufficient material to insure the required finished dimensions of the structure. If large shrinkage is expected, the drawings should be noted, so that the material will not be trimmed too small prior to assembly and welding.

VI. QUALIFICATION OF WELDERS

Skill is so thoroughly an essential of welding that it is necessary to test the welders, prior to their employment in the fabrication of a structure, to determine whether they can make satisfactory welds. Experience with modern welding processes has shown that sound welds made by any particular process will inherently attain a certain minimum strength and other characteristic properties. It follows, therefore, that a welder, who proves his ability to use properly a specified and approved welding process to make sound welds, is adequately qualified to do production welding.

The two tests illustrated in Fig. 17 have been developed to determine the qualifications of welders to be employed in structural welding. The Soundness Test shown is a simple qualitative test of a welder's ability and it is as significant as a more elaborate test, if it is properly interpreted. In use it is both quick and economical.

The Transverse Fillet Tensile Test is useful when quantitative results are desired and it can be made for less than $2.00 per specimen. The machining of the

welds guarantees a uniform basis for all tests and it emphasizes the importance of good penetration at the root of the weld. The assembly and preparation for testing are illustrated in Figs. 18 and 19. This test also shows the soundness of the weld because fracture always occurs in or along the welds and not in the joint material. In several years of practical use it has been very effective in showing the progress of new welders and checking the work of experienced welders.

The soundness of butt welds is ordinarily determined by means of nick break tests which are relatively simple and inexpensive. Tensile tests of butt-welded joints are expensive and they have been found unsatisfactory as welders' qualification tests because they test the joint material more than the weld. Bend tests, which measure the ductility of the weld rather than its strength, are now commonly used as qualification tests for butt welding because they are both effective and reasonable in cost.

VII. WELDING

The actual welding of a structure is only one of the many operations required in its production. The welding process, equipment and materials and the welding operator having been proved adequate for the work, there remains only the actual deposition of the weld under proper supervision. The welder must choose the electrode and welding current for his work and he must exercise careful judgment in the welding sequence he uses.

The choice of electrode size is governed by the nature of the joint to be welded and its position. The welding current, within the limits practicable for the size of electrode chosen, is governed also by the detail of the joint. The ordinary applications of various sizes of electrodes and the currents commonly used in structural welding are shown in the table in Fig. 20. The chart in this figure shows the deposition rates, at various operating factors, for a commonly used type of electrode. If the welding conditions for a job and its probable delays are known, this chart is useful for estimating production time and welding costs.

The manner in which welding affects the distortion of the work and its final shape, dimensions and stresses also must be considered by the welder. He cannot limit his work to a mere deposition of welds. The behavior of framed structures during welding is not predictable, however, beyond the simple statement that welding always causes shrinkage and the important basic principle: A structure, which is inherently rigid or is externally restrained against the shrinkage due to welding, will have little distortion, but high residual stress; and, conversely, a structure, which is flexible or free of external restraint, will be distorted by the shrinkage due to welding, but its residual stresses will be small.

Designers and detailers of welded structures can avoid some of the effects of weld shrinkage and obtain better structures, if they will observe the following practical rules:

1. As far as practicable all welding should be arranged symmetrically about all center lines of a member.
2. Concentration of welds in small areas should be avoided and the total amount of weld should be kept as small as possible, since the shrinkage effect increases as the amount of welding increases.

The shop men, who handle steel regularly, have developed many tricks which aid in controlling the distortion due to welding, but only two methods come within the province of the designer's authority. The first of these is peening and, if it is necessary, the designer should specify its use and the extent to which it is to be carried. Unrestricted peening may damage the weld metal more than it benefits the structure by eliminating distortions. The second method is that of stress-relief annealing, but this is generally impracticable for structural members because of probable warpage which might change the member's shape and dimensions from those required by the design.

The unrelieved weld shrinkage stresses, which exist in framed structures when they are put into service, are probably lessened by the relief which occurs in ductile materials when external load stresses are superimposed on internal stresses. When this does not happen, the applied load-stresses probably cancel the weld shrinkage stresses directly.

Another element which must be considered in the actual welding of a structure is the temperature of the steel when it is welded. Extremely low temperatures aggravate the quenching effect, which may produce undesirable metallurgical conditions in the base metal surrounding the weld. This action will be more serious with thick material than with thin sections and is more pronounced in low-alloy steels than it is in the medium carbon open-hearth structural steels.

VIII. INSPECTION

Visual examination of welds for adherence to specified dimensions and freedom from obvious defects is the most satisfactory means of inspecting the welds of framed structures. The common use of fillet welds and the variety and arrangement of material at the joints virtually preclude the use of those methods which have been successfully used in other classes of welded construction for examining the interior of welds. The use of suitable gages, such as those in Fig. 21, will show not only that the weld is of proper size and shape, but also will indicate fairly well whether the weld has been correctly made. Various common fillet-weld profiles, both acceptable and defective, also are illustrated in Fig. 21, because the appearance of a weld is often a fair indication of its quality. Observation and experience with the actual making, testing and examining of welds will develop more thoroughly, however, the knowledge of weld characteristics which is essential for the visual inspection of welds.

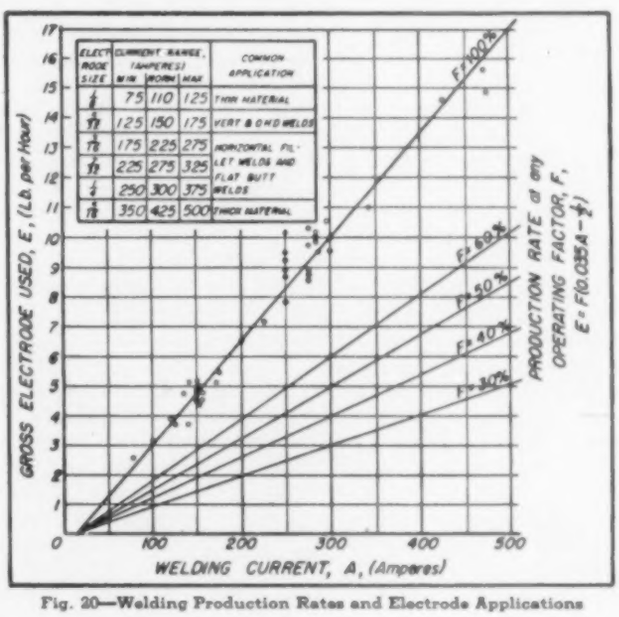


Fig. 20—Welding Production Rates and Electrode Applications

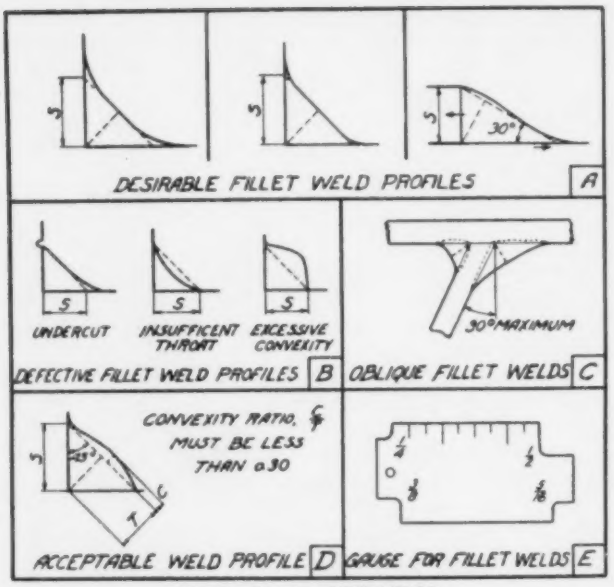


Fig. 21—Details of Fillet Welds

Reliance on this method of inspection, of course, requires previous qualification of the welders and careful supervision of their work. It also demands identification of the work done by each welder. Steel stamps are commonly used for this purpose and they can be readily fitted into the hammer used for cleaning welds. A welder so equipped can make no excuse of lost tools to account for any failure to mark his work.

In addition to examining the weld itself, the inspector should check its location and see that its crater is properly filled and not placed where it will be subjected to prying or tearing forces in service. A common practice, on joints designed to resist calculated stresses, is to carry the ends of the welds around the corners of the connected material wherever possible. This return or "boxing" of the welds generally has a length of only about $^1/_2$ inch and is not considered in the calculations for the design of the joint. It is, however, a worthwhile and economical safety precaution which has been widely accepted in specifications for welded structures.

IX. FIELD ERECTION

The problems of field erection, which are unique with welding, are similar to those which welding creates in shop fabrication. The welder, however, must have ability beyond that of the shop welder because he must be able to climb and work above ground, in addition to his ability to weld. Weather conditions, too, affect field work. Welding cannot be done properly during high winds or storms, nor on wet or icy steel. Extremely cold weather may also prevent field welding, as mentioned previously in the general discussion of welding. Figure 22 shows a large office building in course of erection and illustrates quite well the conditions under which field welding must be done.

Since welded connections ordinarily offer no means of making temporary fastenings to hold erected material until it can be welded, special provisions must be made for this purpose when the joints are designed and detailed. Seated beam connections, for instance, should have holes for two bolts to connect each end to its seat. These bolts will keep the beam from rolling off its seat, and will help also to keep the structure in alignment. The general omission of holes from the members and connections of framed structures is detrimental to speedy and economical erection, because it makes the operations of aligning the structure and holding it together until it is welded extremely difficult. There has not yet been discovered any better clamping and holding device than the common bolt and nut, and any savings gained by the omission of holes must be carefully weighed against the resulting increased difficulty and cost of erection.

When a structure is to be welded in the field it is best to omit all shop paint, unless the material must be stored prior to erection. "Striping" or "cutting" a shop coat of paint so that it does not encroach onto areas in which field welding is required is an expensive operation. The paint coat must be "detailed" on the shop drawings and "laid out" in the shop. A thin coat of linseed oil may be used for material which must be stored and it will not create any difficulties in subsequent welding. It may, however, accumulate a bothersome amount of foreign matter, and unpainted steel is preferable in welded structures wherever it can be used. Painting, after welding is finished, does not differ from ordinary painting practice except that the welds must be carefully cleaned of slag and spatter so that the paint is applied on solid steel.

CONCLUSIONS

The acceptance of welding for bridge construction has been rather slow and only a few welded truss bridges have been built. Welding has been more widely adopted for fabricating plate girders and rolled beam spans and also for repairing existing bridges. Probably more welding has been used, however, for the fabrication of bridge shoes, railings, fascias, curbs and expansion dams and gratings for both riveted and welded bridges than has been required for the stress-carrying joints of welded bridges. Even on all-welded structures such miscellaneous parts and details require a large proportion of the total welding used and their design may have a major effect on the economy of the structure.

Building construction, since about 1926, has provided the greatest opportunity for the development of structural welding. Industrial buildings have been fabricated by welding to gain structural economy or usefulness. Welding has been used also for the construction of hotel, apartment, office and hospital buildings, where quiet erection was essential. Various combinations of riveting or bolting with welding have been tried in attempts to gain economy or other advantages, but none has been

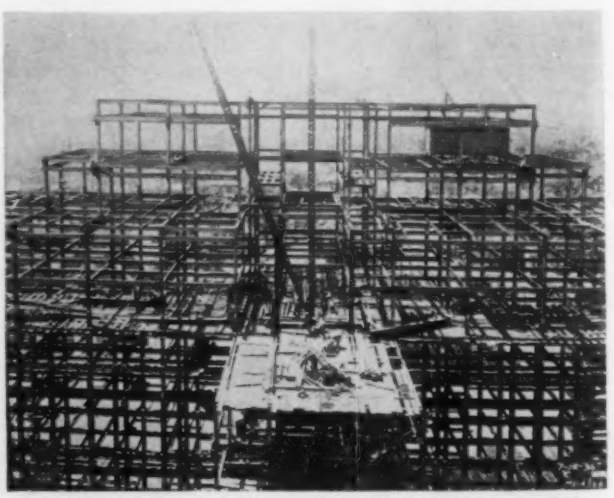


Fig. 23—Erection of du Pont Office Building, Wilmington, Del.

outstanding. Their relative merit usually depends on the individual fabricator's methods and equipment. Welding of auxiliary parts, such as stairs, railings and gutters is, however, generally economical regardless of the method used for connecting the primary joints of the structure.

The AMERICAN WELDING SOCIETY'S two structural codes, the "Code for Fusion Welding and Gas Cutting in Building Construction" and the "Specifications for Welded Highway and Railway Bridges," have grown with the development of welded construction and should be more widely adopted than they are at present. Each of them is planned for use in conjunction with an applicable building code or bridge specification, and when so used furnishes complete rules for the design and construction of a welded framed structure.

The various welding design problems discussed herein have been chosen to show that the designer must carefully analyze his use of material, his joints and his welds to eliminate any fabricating operations which add nothing to the serviceability of the structure. The costs of such unnecessary operations are not now always included in the prices bid for welded steel structures, but as fabricators gain experience in this field all of these extra costs will most assuredly be passed along to the customer.

Welding is an excellent method for joining the steel parts of framed structures, and it is a worthy competitor of other methods of connection. If welding is economical or if it offers other important advantages, it can be used with full assurance that a safe and useful structure can be had.

WELDING OF BOILER DRUMS AND Pressure Vessels*

By R. T. KERNOLL†

DURING our broad and diversified experience in the fabrication of heavy and light wall boiler drums and pressure vessels for the trade, we have been much impressed with the relationship of, and differences between, Codes and Specifications. The usual Codes include A. S. M. E., A. P. I.-A. S. M. E., Federal and State Codes by those states that have adopted same. Generally speaking, most of the state codes are practically a duplicate of the A. S. M. E. Code. This action on the part of some states is beneficial to both fabricators and users. The fabricator will have the assurance that competition must figure on first-class fabrication and the user will be assured of a first-class job. We sincerely hope that other states will fall in line in this good work.

The common applications of the A. S. M. E. Code cover Power Boilers and Unfired Pressure Vessels. It also covers Locomotive, Low-Pressure Heating and Miniature Boilers.

Codes are, to a very large extent, compulsory on both fabricator and purchaser and are uniform in their application. The A. P. I.-A. S. M. E. Code applies strictly to vessels for use in the Petroleum Industry and vessels for other uses cannot be designed under this Code. The main difference in design between the A. P. I.-A. S. M. E. Code and the A. S. M. E. Code is that the safety factor of the former is four and the latter five.

Specifications are written by purchasers and vary in proportion to their knowledge of what it takes to meet their service requirements, ranging from a dimension drawing with or without a code reference up to specifications that are more rigid perhaps than all the codes combined. There is no intention here to underrate the codes. We have traffic regulations that serve the same purpose, but sometimes we find traffic officers waving us along at 45 m.p.h. past 20 m.p.h. signs, and on other occasions they wave us down to 10 m.p.h. in the open country. Codes can never ,entirely substitute for brains.

There is much agitation in some quarters for simplification and unification of codes, although very few concrete suggestions have been made in public. Qualification tests have been reduced and perhaps others could be reduced or eliminated, thus lowering shop costs which could be passed on to the purchaser. However, when the purchaser computes this saving as a percentage of the total fabrication cost, he is certain to want assurance that no hazard has been set up by the elimination of any one step in the test procedure. One important objective of this paper is to indicate which code requirement shall apply, or in cases where he feels justified in stiffening code requirements, he may accomplish his purpose by writing specifications to supplement the code.

Safety is, of course, fundamental and is the basis of every code. It has been said that it is easier to make a weld stronger than to make it weaker than the parent metal. One inference from this extreme view would be that we might as well abandon qualification tests altogether; but we fabricators know very well that in our own interests a certain amount of certified qualifying procedure is necessary.

In view of the increased efficiency we are getting from boiler and pressure vessels since the advent and acceptance of welded construction there is a question in the minds of many whether it costs too much to err on the side of safety.

Every vessel has nozzle attachments, which, if large in number and size may be a big item of expense. The A. S. M. E. Code specifies that the size of the weld is to be determined from the thinner of the neck or shell thicknesses. In the A. P. I.-A. S. M. E. Code the nozzle neck thickness is the determining factor. If the latter code is used, it is obvious in cases where a thick neck nozzle is attached to a light walled vessel, the fillet weld is excessive and causes considerable warping of the light

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† Chief Engineer, Welded Fabrication Division, Edge Moor Iron Works, Inc., Edge Moor, Delaware.

plate. A saving in fabrication cost and a better balanced structure could undoubtedly be realized by revising the dimension specification in such an instance

Our shop manufactures a considerable number of headers, the ends of which are closed by means of shrinking the ends of the shell over a flat head plate and then swedging the ends of the shell over the flat plate. Experiments have been conducted which show that such a header will hold considerable pressure without any welding whatsoever. However, to comply with code requirements, a fillet weld must be used with a throat dimension equal to the thicker of the two plates, which in some cases, is extremely large. In this instance, it seem obvious that a change in the code requirement would make for more rational fabrication.

Code requirements are predicated on sustained pressures and may not be rigid enough in special cases where the vessel is subject to breathing action, sudden changes in temperature or shock loads. Designers of structural bridges and buildings recognize the last condition and increase the sections of members accordingly. Undoubtedly for conditions noted above, provision should accordingly be made in the design of vessels. Jacketed vessels with steam in the jacket space and the charge in the inner shell varying from atmospheric temperature to that of steam will naturally set up strains due to differences in expansion of the inner and outer shells. While a flat head would theoretically be satisfactory, it is much better to use a flanged head whose knuckle radius will permit some flexing. In extreme cases an expansion joint in the jacket shell is necessary.

The codes cover the design of main shell, whereas some shells have a great amount of internals as well as supports, etc. The details and fabrication of these items are largely left to the judgment and discretion of the fabricator and the purchaser has little or no knowledge of how well these parts are constructed. A final inspection does not disclose whether the tray rings or other parts have been welded to the shell with full penetration welds or only fillet welds.

One of the prerequisites to a good job of welding is proper fit-up of seams and attachments to the shell before welding is actually started. The codes allow some latitude in the preparation of plate edges for welding by specifying they are to be either machined, gas cut or sheared. They qualify shearing by making it mandatory that the sheared edges be machined or chipped back $^1/_8$ inch to eliminate possible surface cracks caused by shearing. Unquestionably the machined edge gives the best results but the operation is more expensive than burning. Our company recently manufactured a number of drums 5 feet 0 inch diameter x 10 feet 0 inch long of chrome nickel alloy steel. The outside of the shell of these drums was machined and ground with a minimum wall thickness after these operations of $^5/_8$ inch. We started with $^{13}/_{16}$-inch plate thickness and after rolling, welding, X-raying, heat treating and welding on the heads and trunnions, we found we had held the out of round tolerance to $^1/_8$ inch and had $^1/_{16}$ inch of metal to spare. The code out of round tolerance would have been about $^5/_8$ inch.

Our company has been making increased use of etching the edges of plates to good advantage. All of the work put on our automatic welding machine has the plate edges etched as a precautionary measure. It has been our experience that the enormous heat applied by this machine magnifies the difficulties encountered by welding defective steel to a much greater extent than is encountered in manual welding. Oftentimes we etch the edges which in some cases show bad plate conditions. These defective places show a banded structure up to $1^1/_2$ inches in length and generally running parallel with the plate edges.

We have noticed a growing tendency with the larger companies to write specifications of their own. They naturally include all the local, state and insurance regulations applying to their location. However, they go farther, in that they establish specifications that cover fully their own particular application. Thus, the user will have assurance he is getting a vessel that will exactly meet his requirements but will not be forced to pay a premium for refinements beyond his needs.

BONNEVILLE DAM PRESENTS Varied Use Of Welding*

By PAUL L. HESLOP† and FRED T. DOWNING‡

A LARGE hydro-electric project uses the products and talent of civil, electrical and mechanical engineering and at Bonneville Dam there is wide application of all three fields. Civil engineering is represented by the "heavy construction" of the dam with its spillway gates, the powerhouse with its mass foundation and five-story building, the navigation lock and the fishways. Electrical engineering is represented by the largest generators ever built, the transformers, switchboards and the mazes of switch-gear, wires and auxiliaries. Examples of mechanical engineering are the Kaplan turbines with their automatically adjusted blades, the eleven cranes, four of which can lift 300 tons apiece, the navigation lock operating machinery, several hundred thousand dollars worth of fishway apparatus and the multitude of pumps, compressors and piping.

Illustrating the extent to which the art of welding is employed in the construction at Bonneville seven representative examples have been selected for detailed description, to wit:

a. Manufacture of turbines.
b. Manufacture of generators.
c. All-welded cable drum and truck frame for 350-ton crane.
d. Structural frame for 30-ton gantry crane.
e. Welding embedded gate guides to reinforcing steel for holding alignment during concreting.
f. Field repair of derrick bull ring.
g. Field reinforcement of a derrick due to loading change.

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.
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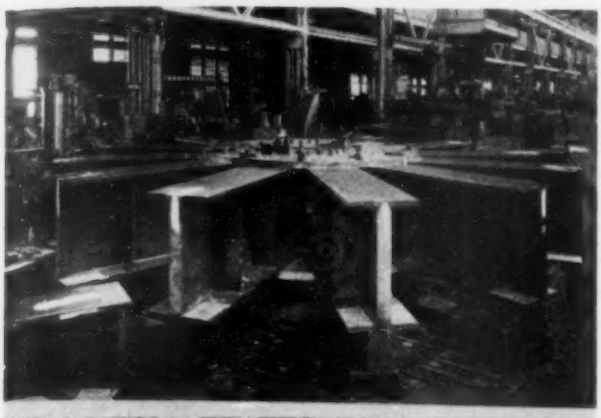
Fig. 1—Revolving-Field Spider Arms for 48,000 Kva. Generators Are Made by Welding



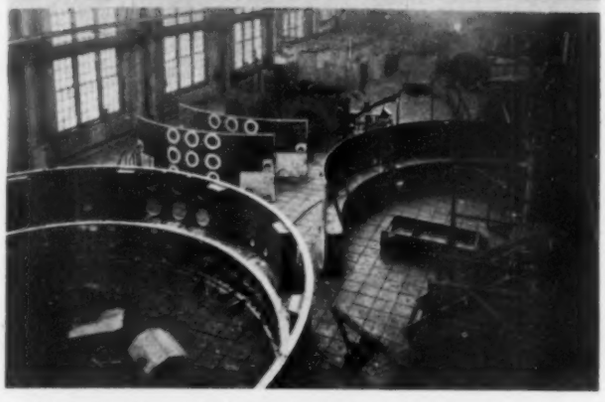


Fig. 2—Stator Frame for Generator Built Up by Welder Mounted on Radial Arm

Each of the two initial main generating units at Bonneville has for a prime mover a 66,000 hp. hydraulic turbine of the Kaplan propeller type, in which the pitch of the blades is automatically adjusted for best operation by the governor. The manufacturer, the S. Morgan Smith Company of York, Pennsylvania, elected to make the large and complicated water passages, stay rings, bearing shells and many other parts by the use of welded construction instead of the conventional castings used in the past. This involved pioneering in this particular field. Description of these turbines has been very thoroughly covered in previous technical articles.[1] Nearly 800 tons of rolled steel plate varying from $^3/_4$ inch to $3^1/_2$ inches thick, requiring about 24,000 linear feet of welding and 29 tons of weld electrode, were used for the two machines. An item of interest is the prewelding of turbine blades, which are subject to the destructive action of cavitation. Based on data collected in other plants, the metal was cut away from those parts of the surface most susceptible to cavitation and replaced with a new surface built up by welding with stainless steel electrode.

The Bonneville generators are the largest, in physical dimensions, of any so far built. They were manufactured by the General Electric Company in their Schenectady plant. The combined weight of generator rotor and hydraulic turbine, totaling 780 tons, is supported on a bearing bracket 34 feet in diameter and fabricated of welded radial arms. Also of welded construction are the revolving-field spider arms shown in Fig. 1. These arms support at their periphery the built-up stacks of laminations and the pole-pieces. The stator housing is also welded (see Fig. 2). The welding machine is mounted on the revolving arm shown at the right of the photo, and the process is semi-automatic in that the rate of travel and feed are mechanically operated.

For handling the spillway dam gates there are provided two gantry cranes of 350 tons capacity each built by the Morgan Engineering Company of Alliance, Ohio. The cable drums for large cranes of this type have heretofore been made of castings, but for Bonneville the manufacturer chose to use welded construction. Figure 3 shows the rolled drum with brackets to receive the slotted end plate. Figure 4 shows the completed drum of all-welded construction with turned grooves. All edges of the drum were processed and the whole is so constructed that the various parts are interlocked and if the welds would separate it is not believed the drum would fall apart. Each drum weighs 25,700 pounds. Further illustration of the use of welding is the truck frame, Fig. 5.

[1] "Giant Turbines for Bonneville," by Curtis W. Lau, *American Machinist*, February 24, 1937.
"Welded Structures for Hydraulic Turbines," by George A. Jessop, *The Welding Journal*, April 1937, **16**, pp. 2–6.
"The Kaplan Turbines at Bonneville," by Paul L. Heslop and George A. Jessop, *Transactions, American Society of Mechanical Engineers*, February 1939, **16**, pp. 97–108.

Fig. 3—Rolled Steel Cable Drum Ready for Welding

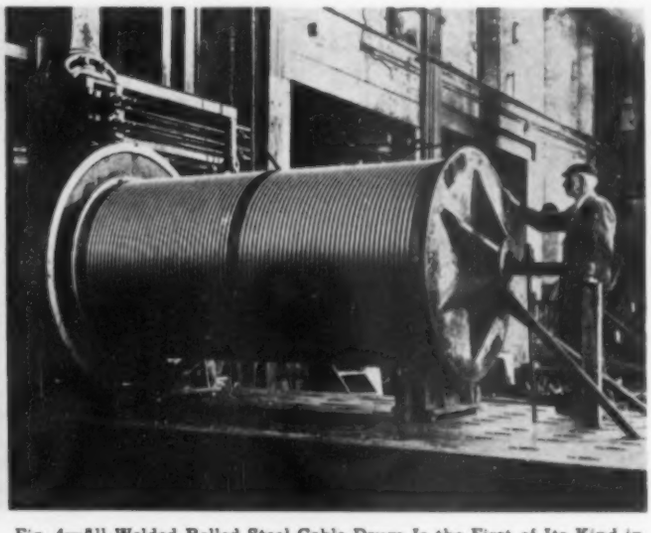


Fig. 4—All-Welded Rolled Steel Cable Drum Is the First of Its Kind in Such a Large Size

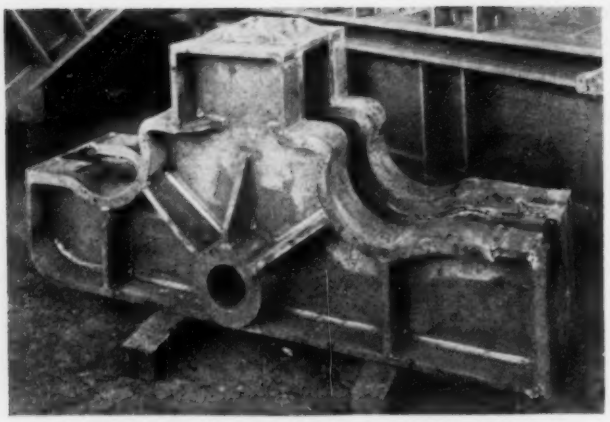


Fig. 5—Truck Frame of Rolled Steel Fabricated by Welding

The stop-logs for unwatering the draft tubes of the turbines are of steel and require a special 30-ton gantry crane to lift them, a view of which is shown in Fig. 6. General specifications for the crane were issued by the U. S. Engineers, but the detail design was made by the manufacturer, Star Iron and Steel Company of Tacoma. The legs of a crane of this type are cantilevers and have to stand racking in all directions. Welding permitted of more economical disposition of material and added considerably to the appearance of the crane, a quality desired by the Engineers.

The vertical roller track and guide beams, for spillway control gates, shown in Figs. 7 and 8, of 12-inch H-section with 12-inch by $1^1/_4$-inch nickel cover plate downstream and 10-inch standard I-beam sections upstream, respectively, were set within a closer tolerance than 0.01 of an inch in five feet. The track beams and guides rise from +24 elevation to +98 elevation, set in the main piers of the spillway dam and anchored with $1^1/_4$-inch bent reinforcing bars every 3 feet through webs of the beams. At intervals of two feet anchor straps on both flanges of beam were welded to reinforcing bars in piers after beams were set with precision instruments. This method afforded an opportunity to correct for slight bending on flanges and possible twist in these rolled sections. In Fig. 9 can be seen the exposed horizontal bent reinforcing bars which served as tie material for anchors on beams. There are two sets of guide and track beams on each side of 19 piers which suggest the magnitude of precision welding performed.

The construction of the 65-ton derricks required an intricate cast steel bull ring shown in Fig. 9. This casting design required adequate ribs and flanges to withstand heavy boom load reactions and thus presenting a difficult casting job for the foundry. The casting was made in six sections, flanged and bolted in ring form in place. During erection flaws in the sides of teeth of casting were detected and thoroughly explored, as shown in Fig. 10.

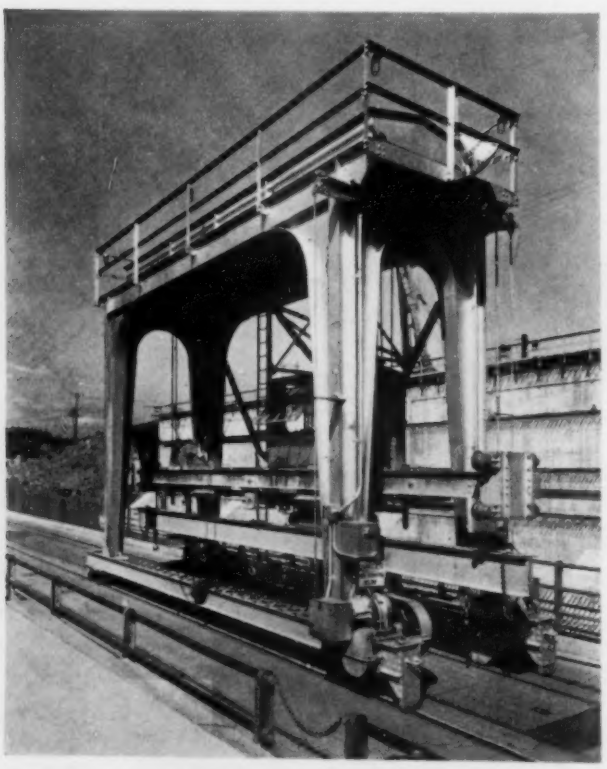


Fig. 6—Gantry Crane Illustrates Pleasing and Economical Results from Welded Construction

Fig. 7—Vertical Roller Track Guides for Spillway Dam Control Gates

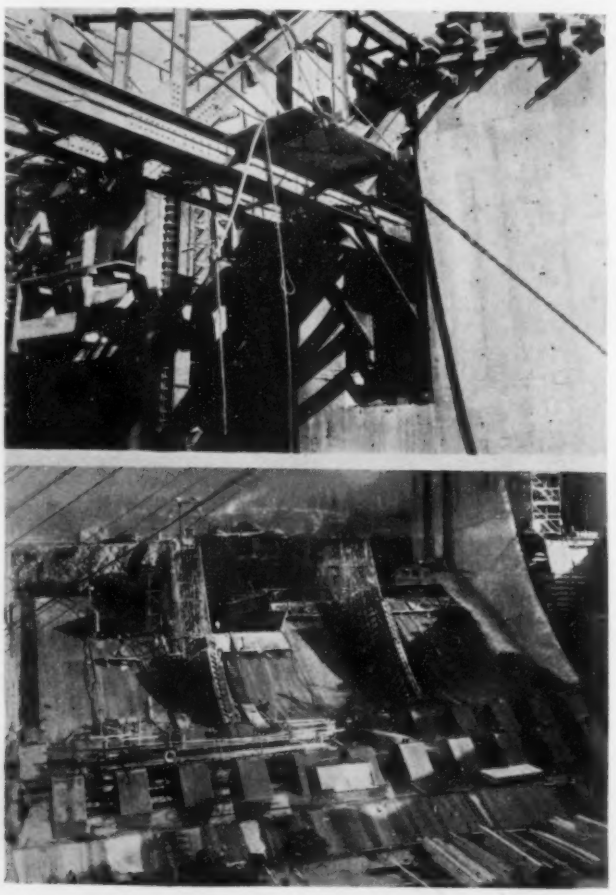


Fig. 8—Slots for Roller Track and Guides, Spillway Dam

The flaws in casting seem to be localized in and adjacent to teeth and not in ring and flanges, so it was decided to weld all pocket flaws.

The gas pockets and porous material were thoroughly removed and each flaw was chipped to virgin metal preparatory to welding. Welding was performed with a soft, ductile rod by the electric process, thoroughly chipping and hammering each pass. During actual welding the surrounding metal was heated with acetylene

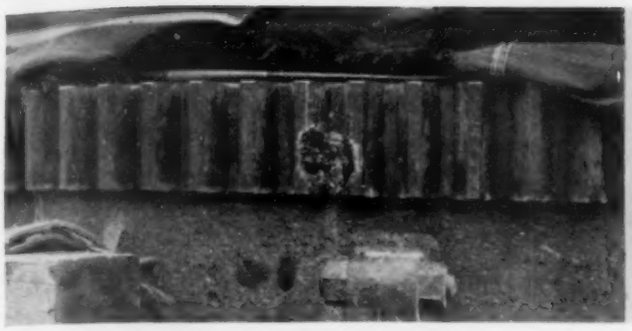


Fig. 9—Cast Steel Bull Gear on 65-ton Derrick

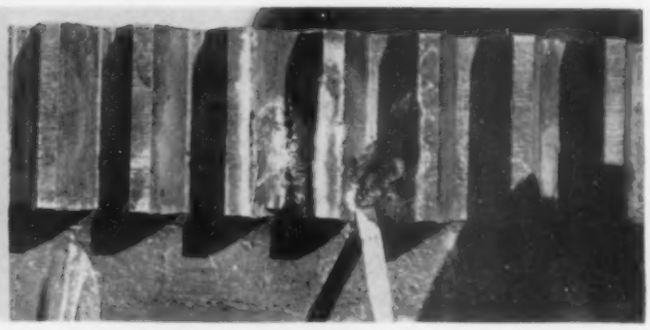


Fig. 10—Shows Flaws in Teeth of Bull Gear on 65-ton Derrick

torch to stress relieve weld and surrounding metal. Completed weld was packed with plastic asbestos and ground lime for annealing.

The entire work was performed in the field on the casting in place, and each welded tooth or backing metal ground to true contour of the original casting. This derrick has been in continuous service for four years and there has been no evidence of excess wear or failure in the welded parts of bull gear.

The alteration to the post type derrick for handling 65-ton ultimate loads was not confined to reinforcement of bull gear alone, but involved the mast and boom point.

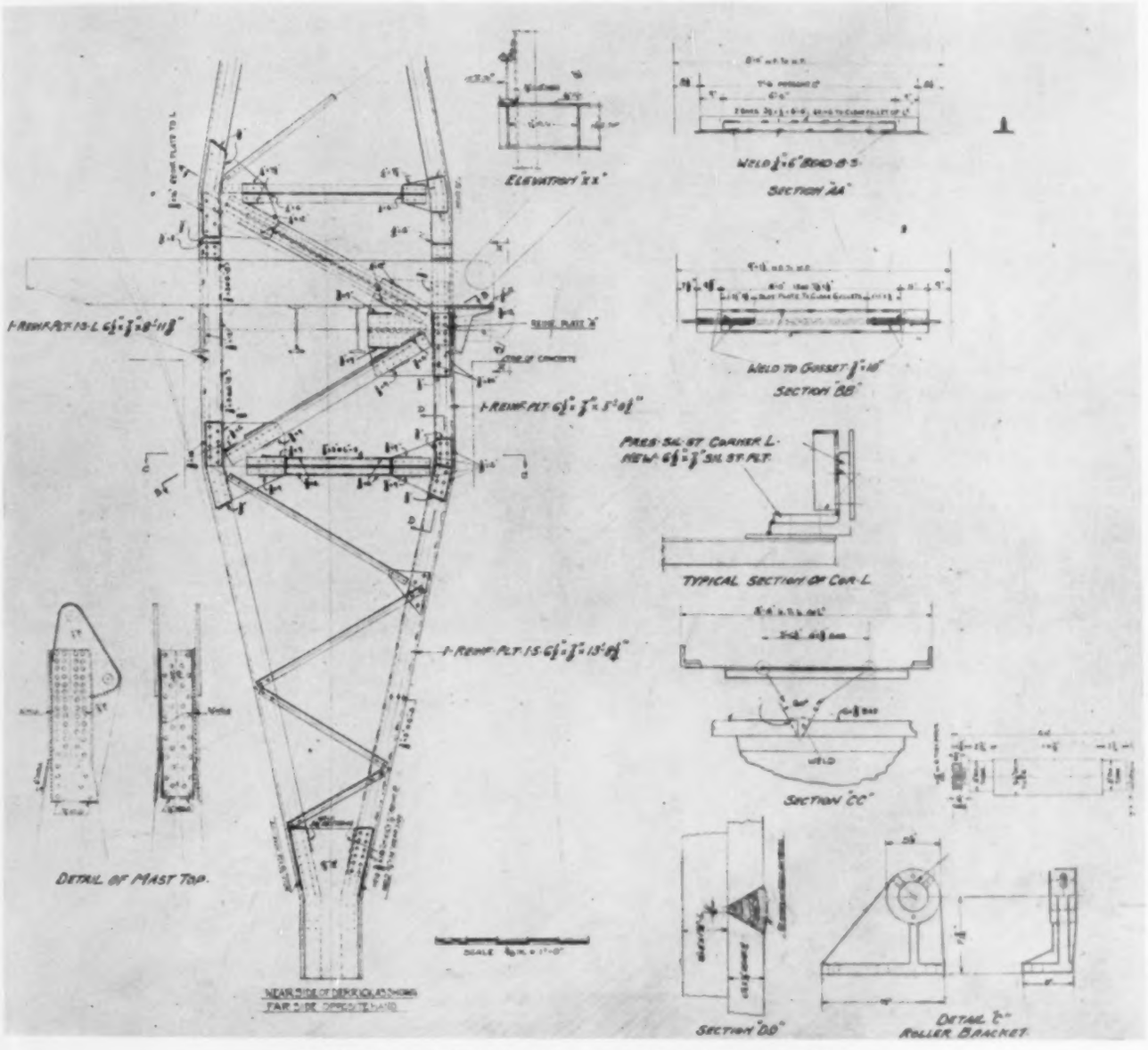


Fig. 11—Diagram Showing Reinforcement of Derrick Mast by Welding

Figures No. 11 and 12 show the welding requirements for reinforcement of the various parts of derrick.

The welding operations on the boom were rather intricate because of the boom point design using a four angle and outside cover plate construction. In the figure can be seen the change in construction necessary to reinforced boom point for additional loading. Four pin plate construction made it necessary to burn and scarf main 6 inch by 6 inch by 1 inch angles and lap weld to stress plates.

All main member reinforcing and pin plates were laid out and cut to template before being pinned to main member of boom. The internal hubs for top sheave, pins and hangers were welded in shop with small pin mandrels in place to prevent distortion and holes bored $^1/_4$ inch undersize. Both sets of hanger and pin plates were mounted and pinned to main angle iron members and $^1/_4$ inch undersize pin mandrels were inserted to maintain gap and alignment. All welds were made with medium tensile steel coated $^5/_{32}$-inch welding rod, each course or pass was hammered and chipped. Preheating was done with light gas torches as welding progressed to insure non-porous and ductile welds.

In order to prevent closure tendencies of angle iron members due to welding on one leg at a time, small plate bosom stiffeners were welded to both legs at six inch spaces. These stiffener plates were removed after completion of welding and boring operations.

Welding operations on the mast of derrick were rather difficult, not only because the procedure involved the performance of flat, horizontal, vertical and overhead welds, but due to the construction of the mast which did not permit easy access to the parts to be welded. The conditions to be surmounted in welding mast are clearly shown on Fig. 11. Several types of welding rods were used to determine the most efficient welding metal for arc welding silicon steel.

High strength rods of various manufacture were not used with any success because of heat stresses set up with high heat necessary for deposition. The angles forming the main members were carefully cleaned to bare metal and stiffener plates welded to bosom of these angles be-

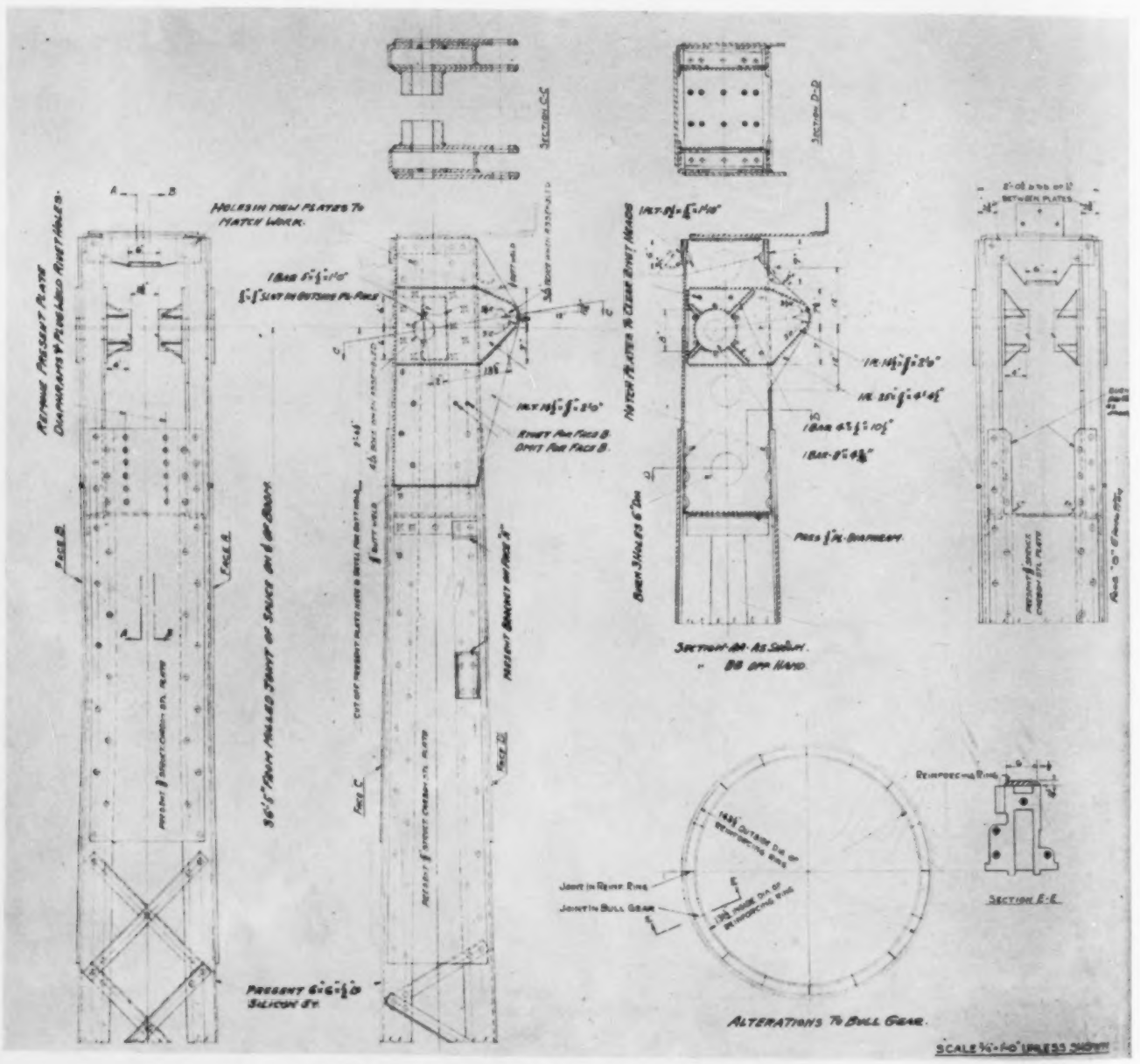


Fig. 12—Reinforcement of Derrick Boom and Bull Gear by Welding

fore welds would set up without cracking. All welding on mast was performed with a medium stress coated $^5/_{32}$-inch electric welding rod, preheating parts to be welded before application.

The foregoing are a few of the uses of welding at Bonneville, but there are many other applications. There are 18 spillway dam gates for regulating the pool, requiring 5500 tons of steel. This job is of riveted construction but the skin plates are welded around their edges for water-tightness, also copper strips are welded to the steel to serve as guides for the removable trash or "skimmer" sub-sections. Forty-five hundred pounds of weld electrode were required for the contract. All of the examples so far discussed have been electric arc welding. An example of acetylene welding is represented by the circular manifold ring of pipe used to supply cooling water to each of the generators. Twelve 2-inch branches were welded in place onto the 8-inch header ring. Too numerous to record are the many instances in which tack-welding was used to hold some feature in place during concreting operations, a standard procedure on heavy construction.

A STUDY OF HEAT EFFECTS in Welding*

By WM. A. PEARL†

THE physical properties of metal to a large extent are the result of heat effects. When heat is applied to the metal after its manufacture, to change the physical properties, it is referred to as heat treatment. These heat treatments, in general, consist of heating the metal to a predetermined temperature, holding it at this temperature for a given period of time and then cooling at a predetermined rate to obtain the properties desired. While it is possible to change the physical properties of metals by heat treatments after it is manufactured, it is also true that temperature, time, and rate of cooling are factors in determining the physical properties of a metal when it is being manufactured. The effect of temperature, time, and rate of cooling on a given metal can be materially changed by the addition of alloys to the metal. There are also other factors that determine the physical properties of a metal and the effect of the heat in welding the metal, for example, hot working and cold working of the material. The effects of these various factors are well known and the effect of heat in particular is readily explained by means of the iron carbon equilibrium diagram.

The heat effects when welding while not always desirable nevertheless are always present and play a large part in determining the physical properties of the weld

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23–27, 1939.
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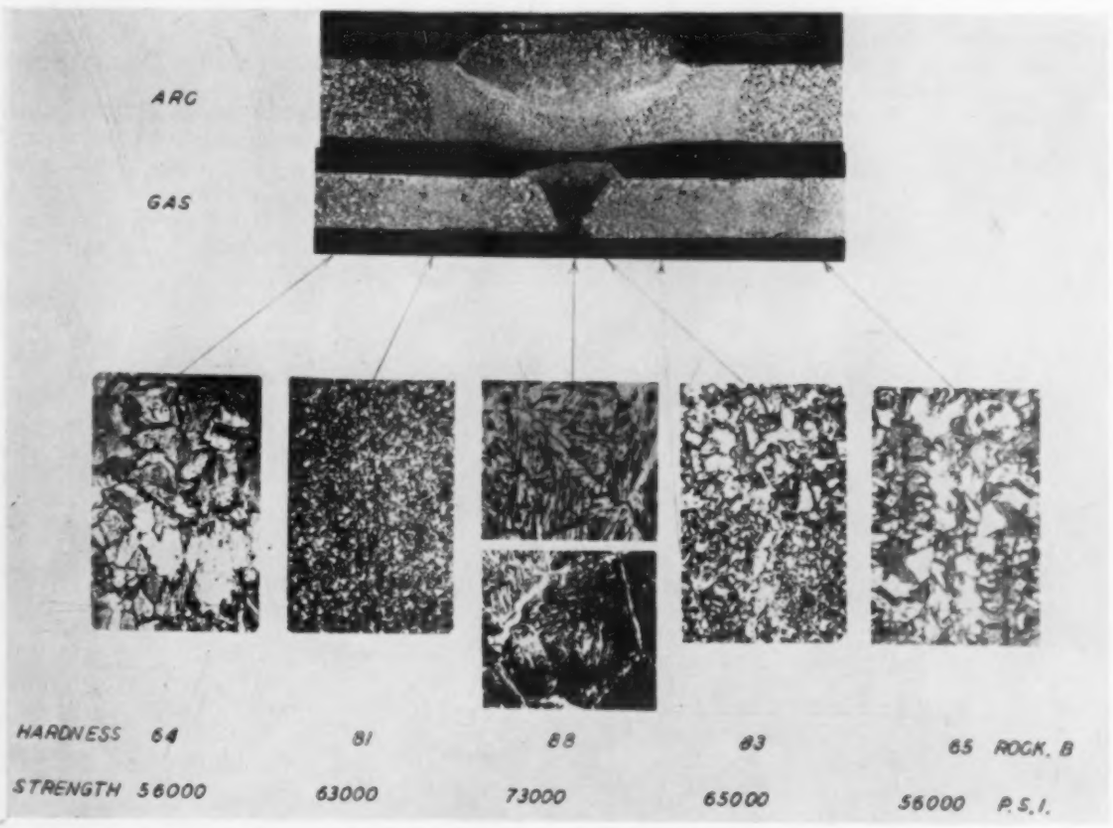


Fig. 1—Structure of an Arc and Gas Weld in Steel

zone. The effects, whether desirable or undesirable, are relatively easily explained from previous knowledge of heat treatments. However, when undesirable, control of these heat effects is not always easily accomplished.

The weld zone, especially in a fusion type, has a number of distinct areas, namely, the deposited metal, the fused metal, and the heat-affected area in the parent metal just outside the fusion zone. This heat-affected zone includes all the metal, the temperature of which became sufficiently high during the process of welding to produce a change in the structure and physical properties of the metal. In ferrous metals it will be all the area, the temperature of which increased to or above the critical temperature range. In a plastic weld no metal is added by means of a filler rod and the result is that the weld zone does not include deposited metal. This type of weld, however, does have a heat-affected zone adjacent to the fusion zone. The weldability of any metal to a large extent is a function of the effect of the welding heat on its physical properties. It is not possible to explain all of the effects of welding heat by illustrating these on one metal, for the effects are different on different metals and also differ on a given metal when the welding procedure and technique are changed. The existence of a critical temperature range in some metals adds to the multiplicity of changes in the heat-affected zone.

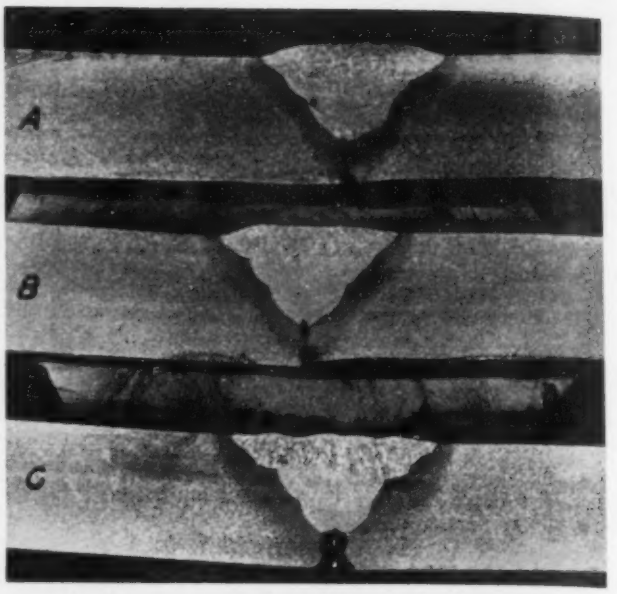


Fig. 2—Macrostructure of the Weld Zone in Steel Using Different Currents

EFFECT OF WELDING HEAT ON ADJACENT METAL

The effects of welding heat on the metal adjacent to the fusion zone may produce any one or more of the following: locked up stresses; relief of existing stresses; increase or decrease in hardness; loss of desirable physical properties such as heat resistance, corrosion resistance and machinability; change in the constitution of the metal; or a change in the composition of the metal. These changes may be accompanied by a decided increase or decrease in the strength of the metal, the ductility, toughness or ability to withstand shock. The changes are always accompanied by metallographic change in the structure and are easily shown by means of a microstructure analysis of the material. The extent of the affected zones is readily indicated by a macroetch of the weld zone. In some cases the affected areas in a weld zone are so narrow it is hard to make physical tests of their properties with any degree of accuracy.

Structural steels, generally speaking, are low carbon or medium carbon steels and may or may not have present alloys that change their physical properties. The critical temperature range for all these steels is approximately 1300 to 1600° F. depending upon the composition of the metal, especially the per cent carbon present. In welding these steels with a filler rod of composition similar to the parent metal using a correct technique it is possible to produce a weld the structural properties of which are superior in many respects to those of the parent metal. Nevertheless the effects of heat are present and a uniform structure across the weld zone does not exist.

A low carbon steel when quenched from its upper critical temperature attains a maximum hardness for that particular carbon content. Due to the low carbon

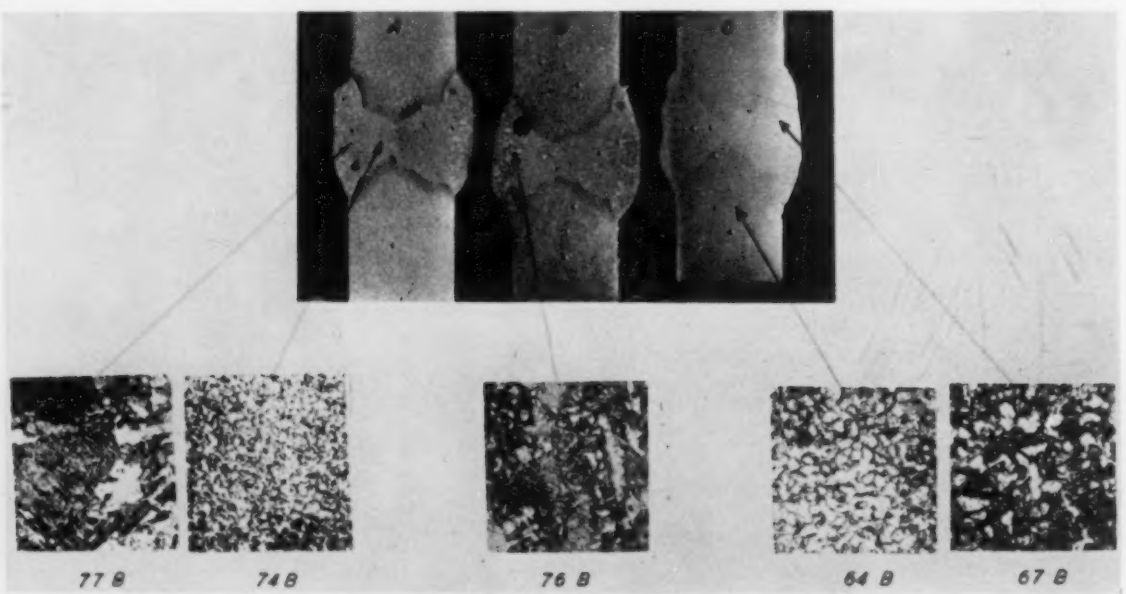


Fig. 3—Effect of Subjecting Weld Zone to Different Heat Treatments

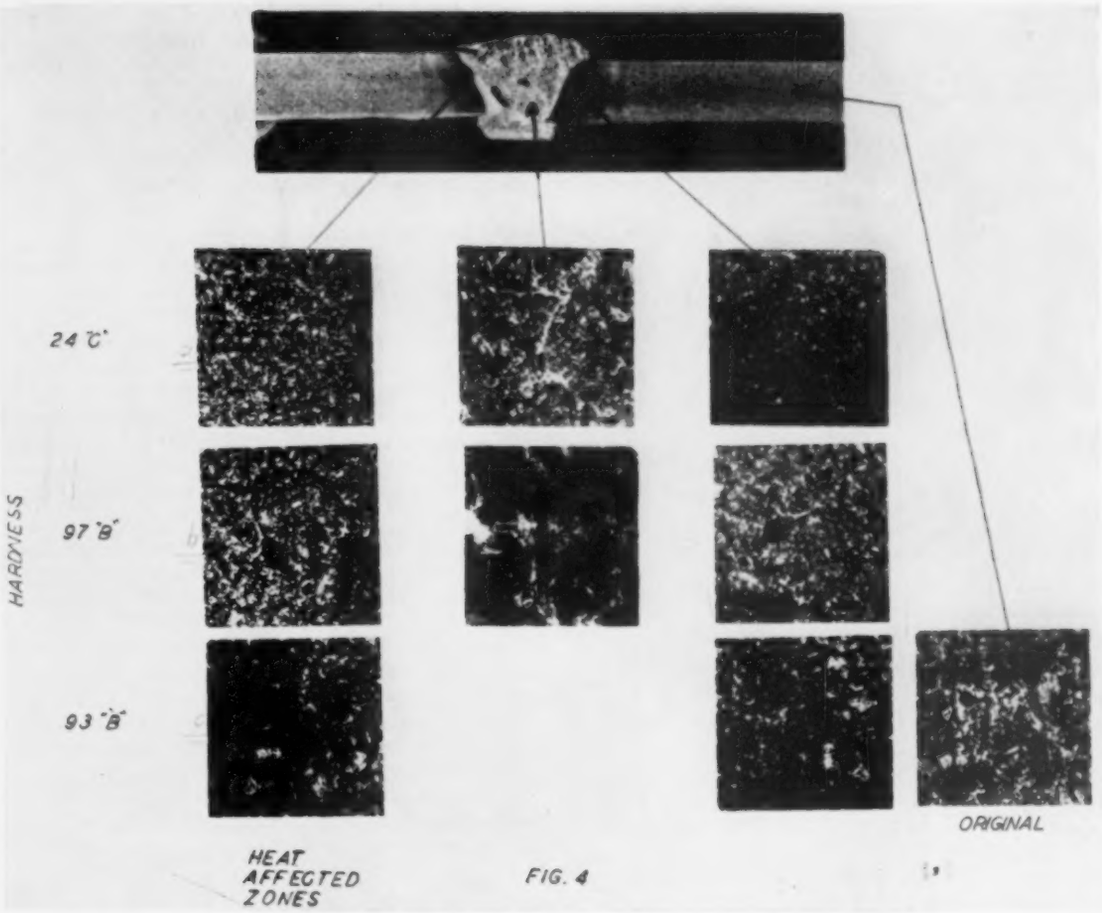


Fig. 4—Heat Affected Zones in a Medium Carbon Low-Alloy Steel

content this increase in hardness due to the quenching is relatively small. It is, however, accompanied by refinement of the grain and an increase in the strength of the metal. The effect of heating this metal materially above its upper critical temperature is to produce coarse grains. The degree of coarseness of these grains and the resulting strength depends upon the temperature to which they are heated and the time they are held at this high temperature. If the metal is worked during the time it is at a high temperature and the working continues until the metal cools to the critical range, a refined grain results rather than a coarse grain.

The weld zone affords all these conditions and others. The deposited metal is inherently a partial quenched cast steel, that is, its structure will be similar to that of cast steel that cooled at the same rate that the deposited metal cooled. At the edge of this deposited metal the fusion zone exists and adjacent to this zone a region exists, the temperature of which became relatively high, in other words sufficiently high to produce a coarse grain. The flow of heat into the parent metal produces zones the temperatures of which approximate the critical range. The cooling in these is sufficiently rapid to give a grain refinement. The width and nature of this heat-affected area is a function of the welding technique, welding speed and thickness of the metal. Figure 1 shows the macrostructure of an arc and gas weld of basic open-hearth steel and the microstructure of the deposited metal, the heat-affected metal and the parent metal. The similarity of the structure of the deposited metal to that of cast steel is readily evident. Also the grain refinement of the affected metal as compared with the parent metal is easily noted. Beneath the microstructure the hardness of each zone is indicated, also the tensile strength.

A decrease in the strength of the metal in the coarse-grained area does not exist when correct technique is used. A coarse grain resulting from excessive tempera-

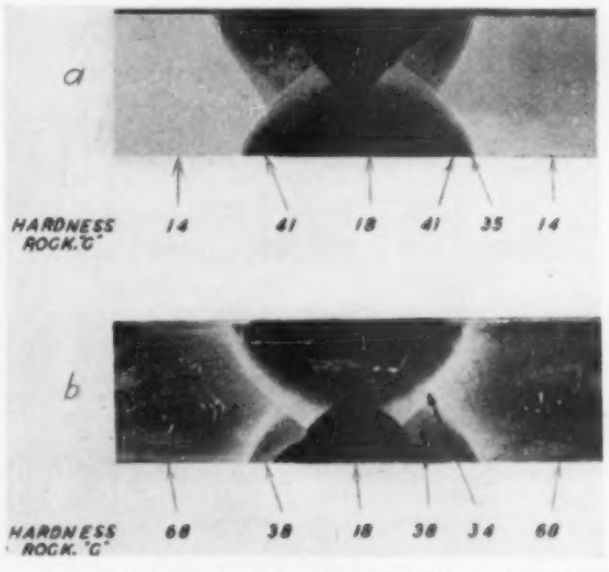


Fig. 5—Effect of Heat of Welding on Parent Metal Depends on Original Condition

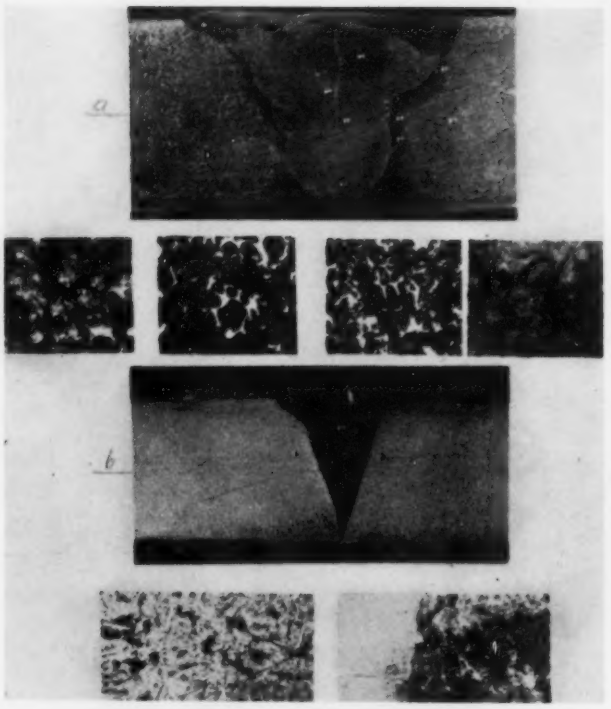


Fig. 6—Structure of Cast-Iron Welds

tures for a period of time usually results in a decrease in strength. Apparently in a weld the time the metal is actually at the elevated temperature is very short and the quench action is sufficient to result in an increase in hardness and strength.

In Fig. 2, the macrostructure of the weld zone of similar metal is shown in the part indicated by (*a*). The affected zone is the result of a welding current of 90 amperes. In the same figure (*b*) and (*c*) show the effect of increasing the welding current on the width of the weld zone. In (*b*) the current was 100 amperes, in (*c*) 120 amperes. The current increase was not sufficient to materially change any of the resulting physical properties. The affected zone is a little wider but the hardness and strength materially the same in all three.

HEAT TREATMENT

In welding it is common practice to partially relieve the effects of heat in the weld zone by what is known as the heat treatment of welds. This is carried on in two different ways; one is subjecting the weld zone to a temperature sufficiently high to relieve strains but not in any way change the micro-structure. The other consists of heating the metal through its critical range, the result of which is to change the physical properties and result in a weld that is practically homogeneous. Figure 3 shows the effect of subjecting the weld zone to each of the heat treatments. In Fig. 3 (*a*) is shown the macrostructure of a multi-bead double vee weld. In (*b*) is shown the macrostructure of the same weld heated to 1100° F. No apparent change occurred in the structure. The same weld normalized at 1600° F. is shown in (*c*). The affected zone has disappeared. Previous to this heat treatment of the weld its strength was greater than that of the parent metal, its hardness was greater and ductility less, but its resistance to impact was less than the parent metal. Subsequent to the heat treatment of the weld, the strength of the deposited metal and affected zone is decreased to approximately that of the parent metal, the hardness approximates that of the parent metal and its resistance to impact has been increased until it is now approximately the same as the parent metal.

In Fig. 3, just beneath the macrostructure of the multiple bead, the microstructure of the center and top of the deposited metal is shown. The grain refinement in the center is a result of heat effects of laying of subsequent layers or beads. In the case of multiple layers or beads the previously placed layers or beads become

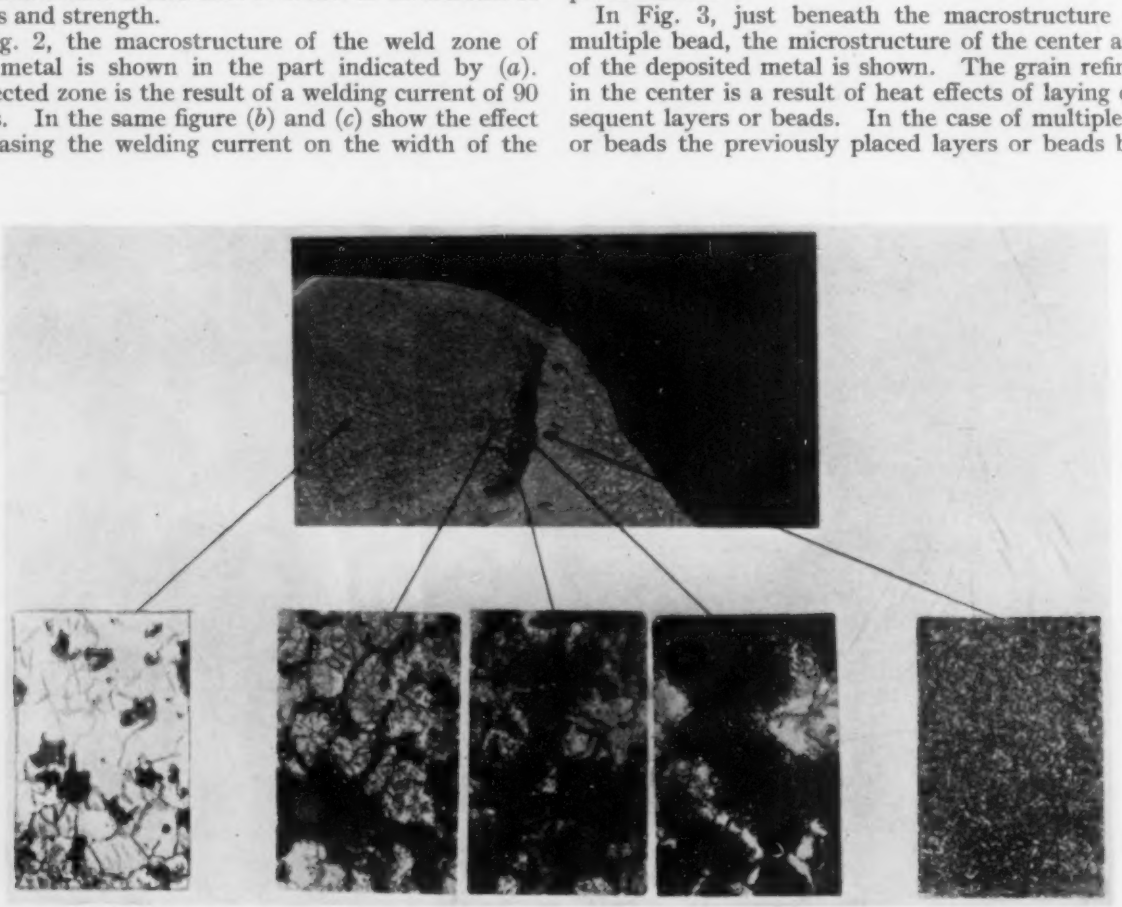


Fig. 7—Structure of Malleable Cast Iron Welded with Steel Filler Rod

part of the adjacent heat-affected area for the subsequent layers and a heat-treating effect results. The cast steel structure disappears as noted in the microphotograph.

As the carbon content is increased in structural steels, the relative hardness in the welding zone increases. In the medium carbon steels a carbon content is reached where it is difficult to weld without preheating due to the extreme hardness resulting in the affected area and the lack of plastic flow in the deposited metal as well as the affected zone. This condition is aggravated by the addition of some alloys, as, for example, in the case of the addition of nickel to the steel. A procedure in these cases of preheating of the metal before making the weld is used to prevent the undesirable heat effects. By this we refer to the increased hardness in the affected zone. It is possible by preheating of the medium carbon steels and subsequent heat treatment to practically eliminate the undesirable effects of heat flow in these welds. In Fig. 4 is shown the macro and microstructure of the affected zones in a medium carbon low-alloy steel. (*a*) indicates the structure resulting from no preheating, (*b*) shows the results of 400° F. preheat, (*c*) 400° preheat and 1500° F. anneal. Beside the microstructure the corresponding hardness of the zones is shown.

As we increase the carbon content to a high carbon steel, additional difficulties arise other than heat effects. The undesirable effects of the heat from the weld nevertheless are present. When hardness in the weld zone is not the important factor but rather strength is of prime importance, other procedures are resorted to when welding these high carbon steels. For example, when welding high carbon steel using a stainless steel filler rod the tendency toward porosity is eliminated. Also heat effects are kept to a minimum. There is, however, a small area adjacent to the deposited metal, the hardness of which will be changed depending on its original condition. If the material is in a hardened condition previous to the time the weld is made a softening will occur in this zone, while if the material is in an annealed condition a hardening in this zone will occur. Figure 5 shows the macrostructure of both the above examples. The hardness of the zones is indicated. In (*a*) the original material was in a hardened condition and in the piece indicated by (*b*) the original material was in an annealed condition.

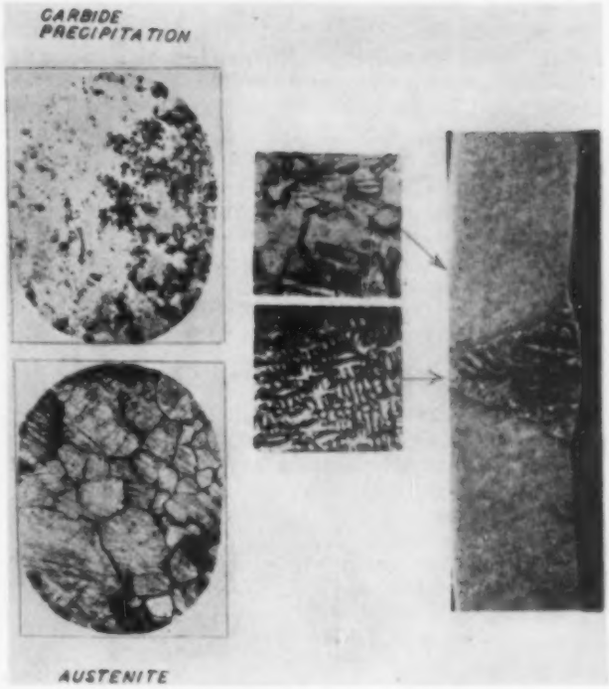


Fig. 8—Structure of the Austenitic Steel

WELDING CAST IRON

When we consider the heat effects when welding cast ferrous material with carbon content above the solubility point, namely cast iron and malleable cast iron, new conditions arise. In the case of gray cast iron its hardness is a function of rate of cooling and per cent of impurities present, most important of which is silicon. The effect of rate of cooling when the casting was made determines what per cent of the total carbon will be in the combined form and what per cent will be in the free or graphitic condition. As the per cent of total carbon present in the graphitic condition increases, a softer material results. If the material is to be classed as gray cast iron, a large per cent of the total carbon must be present in the form of graphite. The effect of heat now becomes one of changing this condition. In the affected zone a temperature is reached sufficient to cause the carbon to go into solution, and the rate of cooling is sufficiently rapid to cause it to totally or at least to partially remain in solution with a resulting increase in hardness which may even give white cast iron in this zone. This heat effect may be reduced to a minimum by a number of methods such as preheating, changing the technique of welding and using special filler rods. However, in these cases other problems arise such as increased shrinkage and cracking due to temperature strains.

In Fig. 6 are shown the macrostructure and microstructure of two cast-iron welds. (*a*) shows an affected zone resulting from welding heat in which a structure change took place. The per cent of combined carbon increased resulting in an increase in hardness. (*b*) shows the result of bronze welding of cast iron. Here no change in the adjacent area is noted. By bronze welding the time and temperature were not sufficient to cause the carbon to go into solution. To what extent this procedure will be satisfactory depends on the condition of the carbon in the cast iron.

In the case of malleable cast iron its desirable physical properties are a result of the heat treatment to which it was subjected after being cast. The white cast iron from which the malleable cast iron is made is extremely hard, brittle and practically all of the carbon present is in the combined form. The heat treatment liberates the carbon as tempered carbon and the resulting metal is ferrite. The heat effect when welding this material is to cause this tempered carbon to go back into solution in the affected zone and eliminate the malleability.

Figure 7 shows the macro and microstructure of malleable cast iron welded with a steel filler rod. The tendency of the temper carbon to go into solution is easily recognized. In other words, the metal tends to return to cast iron in the heat-affected zone.

WELDING AUSTENITIC STEELS

There are a large number of ferrous metals on the market, the properties of which are a result of large percentages of alloying materials. The most common example of this is what is ordinarily known as austenitic steels. The presence of the alloys causes the carbides to remain in solution. The carbides are kept in solution by a drastic quench of the material from a temperature of about 1950° F. The microstructure of these aus-

tenitic steels shows only ferrite grains with some strain lines present. When in a heat-treated condition these materials are high in strength, machinable, tough and corrosion resistant. If this material is heated to a temperature of 1500 or 1600° F., held at this temperature for a time, and cooled slowly, the carbides precipitate out. The result is the metal is hard, non-machinable, and in the case of stainless steels, non-corrosion resisting. When welding this material, the conditions in the affected zone are such that this precipitation may take place. In Fig. 8 is shown the structure of an austenitic steel previous to the time the weld was made, also the structure in the affected zone after the weld was made. A large precipitation of carbides will be noted in this zone. It is possible to restore this affected zone back to its original condition by applying the drastic quench to the material after the weld has been made. Other methods of attempting to prevent these undesirable heat effects are used, for example maintaining the per cent of carbon in material to a minimum, addition to the austenitic steel of alloys such as titanium or columbian that act as stabilizers.

Not only in the ferrous field but also in the non-ferrous field heat effects are present. For example, in the case of cold drawn copper, its strength is increased frequently as much as 40% by the cold working. The effect of heat when welding this is to anneal the zones adjacent to the deposited metal with an accompanying loss of strength and a material decrease in hardness of this area of the parent metal. Likewise in the non-ferrous fields there are many other examples of heat effects; for example, among the alloys containing zinc there is a loss of this alloy in material in the weld zone. In welding of nickel the heat affected area tends to become large grained with a wide grain boundary.

CONCLUSION

From the foregoing discussion it is evident that among the problems involved in welding the effect of heat in the weld zone is one of the important factors in determining the physical properties of the weld zone. In some cases these effects are not at all undesirable; in other cases they are very undesirable. Many methods have been devised to attempt to eliminate the undesirable heat effects. In some cases procedures have been entirely successful and in other cases only partially successful in eliminating these undesirable effects.

WELDING HEAVY PRESSES*

By L. J. McDONOUGH and J. R. HENRY†

THE Clearing Machine Corporation is located in the Clearing Industrial District of Chicago, Illinois, and is engaged in the building of sheet metal working equipment. The record of advancement that has been made in press design through the use of welded steel construction parallels that of the automotive and aeroplane industries. The Modern Press has streamlined styling, smoother action and greater accuracy. It is more efficient and requires less factory floor space.

Press design up to 5 or 6 years ago was practically static. Structural members were made of heavy iron castings and the design was confined to known foundry practice. The gearing, crankshafts and levers were mounted outside of the main structure and left exposed. The presses were massive and grotesque in appearance. It is interesting to note that the presses were sold on a cost per pound basis rather than on a capacity basis. Weight was not considered an undesirable feature as it provided additional rigidity and decreased the possibility of overload failures.

The development of deep drawing steels created a demand for presses of increased capacity and precision. High production manufactures, such as the automotive industries, demanded special-purpose custom-built presses with smoother action, more tonnage, greater accuracy and lower operating costs. Likewise they demanded short time deliveries. The realization of these conditions prompted Clearing Machine Corporation to develop presses which would answer these demands. They set up plants and equipment for the economic fabrication of such presses and the various items of procedure and production set forth herein.

* To be presented at Annual Meeting, A. W. S., Chicago, Ill., Oct. 23–27, 1939.

† Welding Superintendent and Welding Engineer, respectively, Clearing Machine Corporation, Chicago, Illinois.

DESIGN CONSIDERATIONS

In attacking the problem of an entirely new press design to meet the varied requirements of industry, new materials and methods of construction were considered. The structural members of cast-iron presses frequently failed because of tensile fractures. These failures ordinarily required the replacement of the entire structural member which caused a long delay and expense in returning the press to production. Steel construction provided a means of overcoming this trouble for it is a ductile material and has a tensile strength far greater than the best grade of cast iron.

A press is essentially a hollow box frame supporting a slide with a means of exerting a load between the slide and the bed of the hollow frame. The CLEARING press frame is built up from four major units consisting of a bed, a crown and two uprights.

BED

The bed or base of a press is basically two large "I" beams supported at the ends by tie-rods, and uniformly loaded through a part of the length; the load being the pressure applied by the press. Beds are ordinarily designed to have 0.001 inch deflection per foot of length at rated load. In order to obtain the required rigidity with a reasonable weight and depth of bed, it is evident that it should be made of steel which has, on the average, a modulus of elasticity $2^1/_2$ times that of cast iron.

Large steel press beds run up to 32 feet in length by 9 feet in width by 10 feet deep and in rated capacity up to 3000 tons. The material in such a structure must be carefully distributed so that it will provide the maxi-

mum rigidity without excessive weight. The flanges, which contribute the greatest amount to the rigidity, must be made heavy, whereas the webs need only be thick enough to transmit the horizontal shear. On a large press bed of most economical design, the flanges run from 6 to 10 inches in thickness by 16 to 18 inches in width. The corresponding web thickness need be only $1^1/_4$ to $1^3/_4$ inches thick. Cross ribbing and end enclosures are made of still thinner plates. Such beds approach 70 tons in weight.

Steel foundry practice does not permit the use of such a design, for at points where the plates intersect it is impossible to make a cast-steel bed with such wide variations in plate thickness. We have found that cast-steel beds run at least 20% heavier and very few foundries are available to handle these large structures. Cast-iron beds are much heavier than cast-steel beds and they are necessarily deeper and more massive to give the same rigidity. The foundations required for cast-iron beds are considerably deeper and more expensive than for a corresponding welded steel bed.

SLIDE

A press slide is essentially a reinforced hollow box type structural member consisting of a flat bottom plate with vertical stiffener plates supporting one or more horizontal bearing plates. The number of bearing plates is dependent upon the number of points of suspension specified in the design requirements of the press. Vertical bars are placed at the four corners of the slide to provide a machined surface for guiding the slide in the gibs. The slide is bolted to the driving plungers through a nut and lead screw adjustment for changing the die space of the press. This adjustment is accomplished by a remote controlled gear reduction motor and the entire mechanism is mounted in the slide.

Slides are designed to give 0.001 inch deflection per foot of length at rated load. The bending moment of the slide is considerably less than that of a bed and they are considerably lighter in wieght. Roughly, a slide weighs about one half that of the bed. The cast weight of a slide is generally 10% heavier than a corresponding welded structure.

UPRIGHTS

Uprights are rather simple box construction compression members which space the crown the proper distance from the bed and support the gibs which guide the slide.

Uprights are designed to have a minimum cross-sectional area considerably greater than the tie-rods which apply the compressive load to them. Ordinarily they are fabricated from $^1/_2$ to 1-inch plate depending upon individual load requirements. Uprights run up to 10 feet in width by 2 feet in thickness and 15 feet in length.

Cast-steel uprights run from 50 to 100% heavier than corresponding welded uprights depending upon the thickness of plates required for the welded upright.

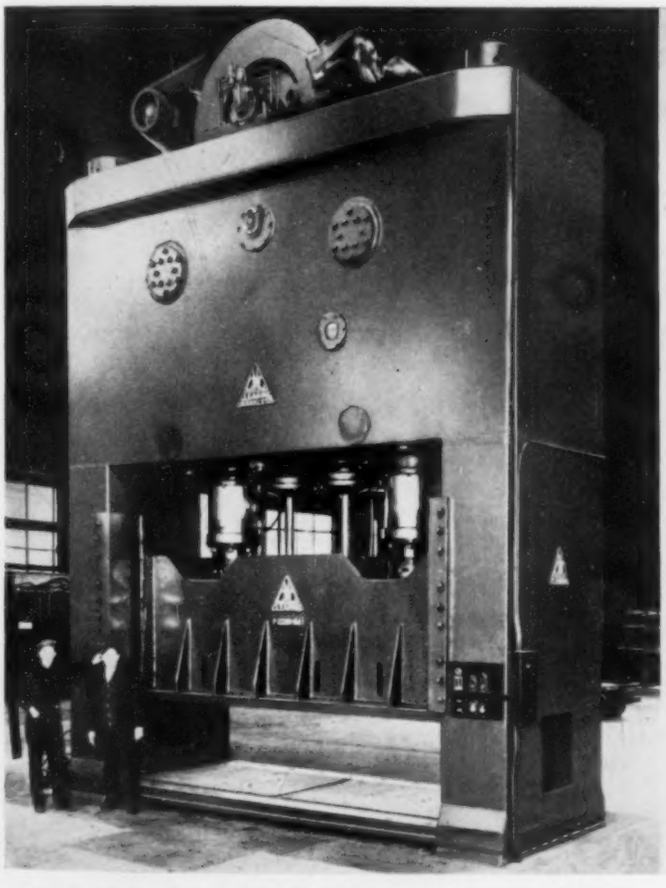


Fig. 1—A Typical All-Welded Steel Press Showing the Smooth Finish and Neat Appearance Obtainable with Plate Steel Fabrication. This Press Has a Pressure Capacity of 2200 Tons with a Die Space of 164 Inches Between the Uprights, and Was Designed for the Forming of Steel Ends for Box Cars

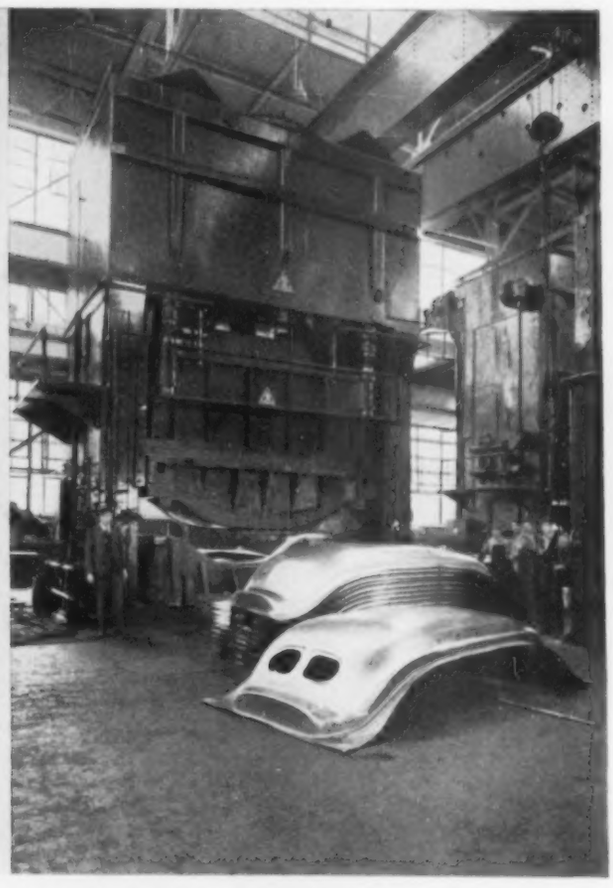


Fig. 2—A Large All-Welded Steel Press Installation in a High Production Body Plant. The Press Is a Triple Action Unit with Four-Point Suspension on All Three Slides. It Has a Die Space of 180 Inches Between the Uprights and a Pressure Capacity of 1800 Tons

Fig. 3

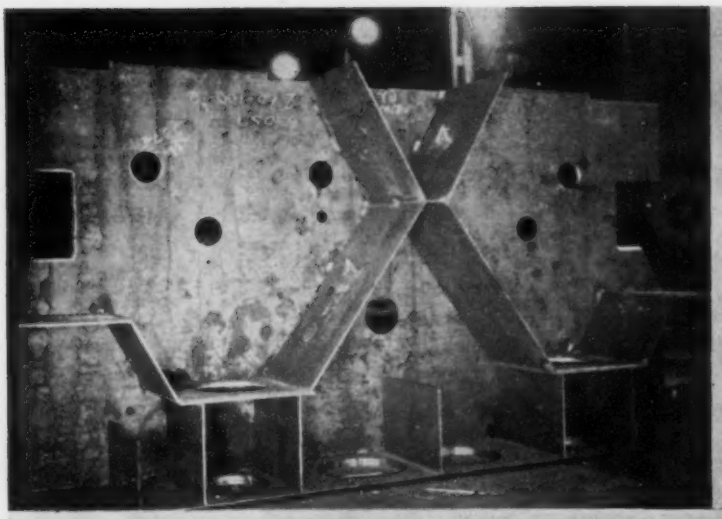


Fig. 4

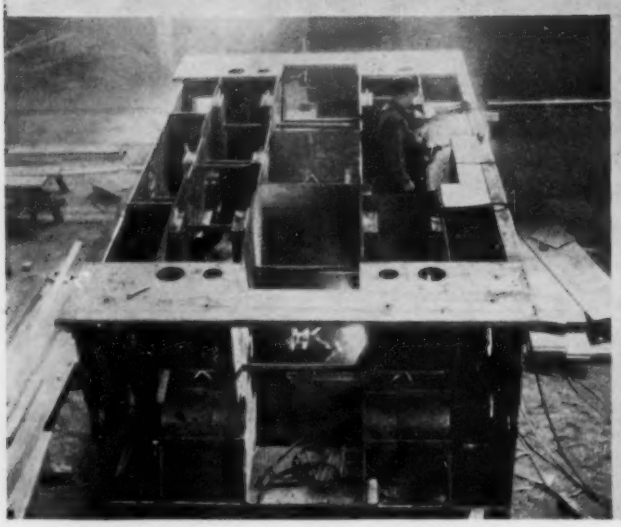


Fig. 5

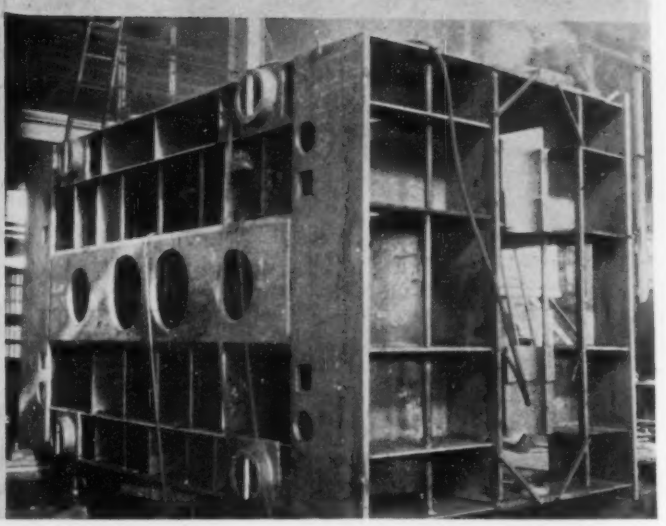


Fig. 6

Figs. 3, 4, 5 and 6—Photographs Illustrative of the Assembly and Welding Procedure Used in the Fabrication of a Double Action Press Crown

CROWN

The crown is the part of the press that houses the entire press drive and is the most complicated structure on a press. Crown sizes run up to 10 feet in width 11 feet in height and 32 feet long. Crown weights run up to 70 tons. A large percentage of the plates in crowns need not exceed $^3/_4$ of an inch in thickness. There are, however, a considerable number of pieces forming bearings and pads which are up to six inches in thickness. Flanges are generally $2^1/_4$ to $2^1/_2$ inches thick. Here we have a wide variation in plate thickness with heavy sections adjoining large and relatively thin plates. It is a very good example of the flexibility of welded design in which the right amount of material can be placed where needed without increasing the material at a point where it is not needed. Generally, cast-steel crowns run from 40 to 50% heavier than corresponding welded crowns.

MISCELLANEOUS WELDED PARTS

There are a large number of smaller parts for presses that are fabricated in addition to the major parts already mentioned. These parts vary from brackets weighing 50 lb. to pressure pads which run up to 10,000 lb. each. We find that such parts that are ordinarily steel castings, can generally be completely fabricated for the cost of the pattern.

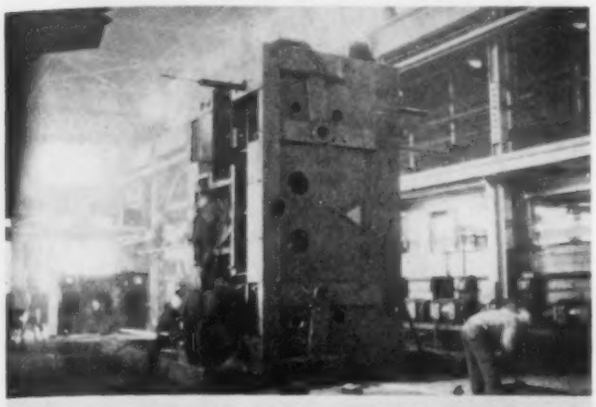
Steel castings still play an important part in welded design and they are used wherever it seems most practical. Cast-steel inserts, bearing supports and special shapes are fitted into the fabricated plate assembly and welded to form the completed unit.

WEIGHT AND COST COMPARISONS BETWEEN WELDED AND CAST-STEEL PRESS PARTS

Because of high pouring temperatures steel castings are difficult to make. The pattern and foundry charges are high, and the casting weight is generally higher than necessary because good foundry practice prohibits the free use of light and heavy sections to provide maximum rigidity with a minimum of weight.

A specific example will illustrate more clearly the weight and cost advantages of welded steel press parts over the corresponding cast parts.

Fig. 7—Shows Double Action Crown Placed on End for Welding



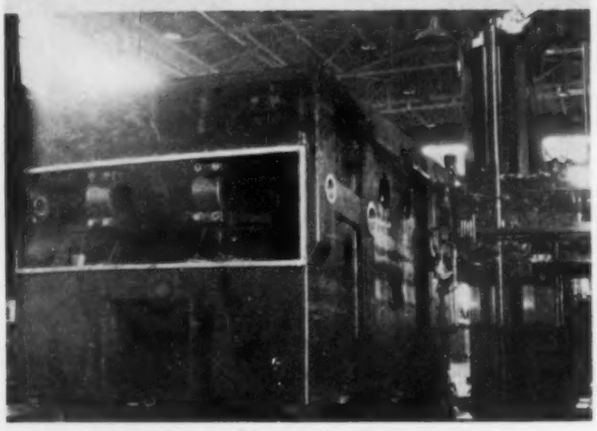


Fig. 8—Shows Welded Steel Crown Being Machined

The welded weight of a crown for a specific press is 70,000 lb. The cast weight is 105,000 lb. The corresponding weights on the bed are 50,000 and 60,000 lb.; on the slide 30,000 and 33,000 lb.; on the uprights 25,000 and 37,000 lb. The total weight of these parts as welded is 175,000 lb., whereas the weight as cast is 235,000, lb. or an additional weight of 60,000 lb. on one machine.

If it is assumed that welded steel and cast steel each cost $6\frac{1}{2}$¢ per lb., then the added cost of the cast-steel parts would be $3900.00. The patterns for the castings would run at least $2600.00, which in the case of large presses must ordinarily be absorbed by one machine. The additional cost of the cast parts then totals $7500.00 for one press.

The machining time for our large cast-steel structures is always more than for a corresponding welded structure. The finish allowances on castings are considerably more than we allow on our welded structures, and the machining time to remove this excess stock is generally 20% greater than for corresponding welded parts. The machining problems on cast structures are more serious because of frequent sand inclusions and hard spots found on the machined surfaces.

In testing the oil compartments of our cast-steel crowns we are frequently confronted with a porous wall section. In a welded structure, oil leaks are seldom encountered, and by comparison they are easily repaired.

COMPARISON OF WELDING TIME AND CASTING TIME

The delivery requirements on large presses are very short considering the design time and amount of work involved in manufacturing such machines. The delivery time seldom exceeds 15 weeks even for the largest presses. The necessity for quick fabrication is therefore evident, inasmuch as a considerable part of the time is required for design. This requirement practically rules out steel castings, which, in the sizes required, take 7 to 10 weeks for making the pattern and casting.

Welded plate construction provides a quick, efficient and economical means of meeting these requirements. It provides a virtually unlimited freedom of design, and has so materially reduced the weight and size of a given press that it is now sold on a capacity basis rather than the customary total weight basis.

In cases of great necessity we have fabricated crowns of 70,000 lb. in six working days of three shifts each. Large beds and slides are ordinarily fabricated in one week's time working three shifts. Uprights can be welded in a few days.

WELDING DETAIL & SHOP DRAWINGS

Our welding design calls for the construction of a homogeneous structure built up from a series of parts prepared from plate steel. Our Welding Standards specify the complete absence of cracks in load carrying sections that are subjected to repeated tensile loads. With the exception of auxiliary ribbing and stiffeners that carry no tensile load, each joint is required to be 100% homogeneous with the complete absence of synthetic cracks.

The welding detail for all such work is prepared by a special section of the Engineering Department. This Welding Engineering Division is responsible to the Engineering Staff and works in close cooperation with the shop and the design departments. The importance of this Welding Engineering Division warrants a functioned study of its duties. It has the following responsibilities:

1. Consults with designers regarding design and load requirements of welded parts.
2. Sketches each plate of welded assemblies giving the joint preparation required.
3. Issues manufacturing procedure for each part of a welded structure and indicates the assembly sequence.
4. Specifies all welding.
5. Issues purchase order requisitions for steel and maintains a working inventory of plate material on hand.
6. Keeps a close contact with the job in the shop and notes the design or procedure improvements, of practical value, that originate in the shop.

With such an arrangement we have the planning done by a select group who know the design requirements for each joint and are able to take advantage of economies in fabricating and welding procedure.

The sketches made by the Welding Engineering Section are given the same drawing number as the assembly print, plus a detail number. This detail number is marked on the assembly print so as to locate the particular plate in the assembly. The plate sketches are issued to the Burning Shop and the drawing number and detail number are painted on each part as it is prepared for assembly.

The joint preparation and subsequent welding procedure is carefully planned to provide for a minimum of material handling. The assembly and welding sequence are planned to provide a minimum of manipulation during welding.

The practice of maintaining a steel inventory and the issuing of purchase order requisitions for steel by this group minimizes scrap and expedites material processing. In frequent instances a rush job has been expedited by making minor alterations to permit the use of materials on hand.

A close follow up of the job during fabrication is automatically obtained by the responsibilities placed on the Welding Engineering Group. Experience is a good teacher and we strive to profit by the design and procedure improvements that originate in the shop.

THE WELDERY

Our Fabrication Department was planned, organized and equipped to manufacture large weldments for commercial consumption in addition to facilities to handle our regular line of press. We are equipped to handle heavy structures up to 100 tons and have annealing facilities that will handle anything that can be shipped by rail. We have one of the largest automatic welding machines in this country, and can handle high production work in addition to the customary job shop lots.

The Burning Shop is a plate fabrication department in which all plate material is prepared for welding. All material prepared in the Burning Shop is made according to the plate sketches issued by the Welding Engineering Section. The shop is equipped with the latest type of portable and shape cutting machines. All large plates and plates requiring long straight or circular cuts are flame cut with portable machines. Parts of intricate shape, small parts, and parts which are to be duplicated are flame cut on a large two torch, two directional type shape cutting machine. Our largest machine will cut over an area of 6 feet by 31 feet, and under ordinary working conditions the machine is kept in continuous operation by having two template and cutting areas.

Successful manufacturing operations are dependent upon small economies, and as an example we point to the operating efficiency of the work tables on our large shape cutter. The table of this machine is of unique design and has created considerable comment among visitors at our plant. The table consists of separate upright members the width of the cutting area spaced every 7 feet along the length of travel of the machine. "T" bars with copper strips bolted to the leg of the "T" are laid from one upright to the next. These "T" bars are loose and can be slid toward or away from the cutting area. With such a design it is possible to shape the table to suit the job. This feature is particularly advantageous when close spacing is required for cutting small parts from salvage material. For cleaning purposes the bars slide out of the way and the slag and scrap metal is removed from below the table with an overhead magnetic crane.

As mentioned previously, this machine has two template tables and is kept in continuous operation by having a set-up man plan the next job so that the lost time delay between jobs is reduced to a minimum.

The Burning Shop layout is arranged to provide a minimum handling of steel once it enters the shop. Complete layouts are made on each part to be cut on the portable machines. The bevel preparation is indicated and the plates are marked for identification. These detail marks are on the piece as it moves to the assembly floor. Those parts that require machine cut bevels as an additional operation are transferred by crane to the machine shop and processed.

Scrap loss is ordinarily one of the major items in the cost of cutting operations. We flame cut our parts from standard size plate material, and it becomes very important that we utilize the scrap material for making smaller parts. We attempt to salvage scrap material by storing it "on location," thus making it more convenient for the operator to use the irregular shape in front of him than to obtain a standard size sheet from which to cut small parts.

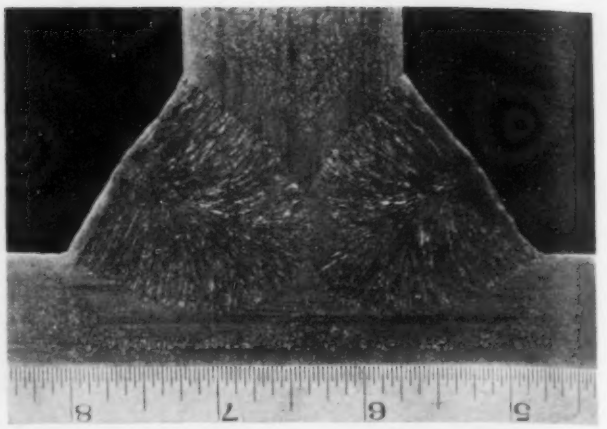


Fig. 9—Macrograph of the Welded Joint Connection for "I" Beams with 1 1/2-Inch Web Used in Press Bed Construction

Material is transferred in group lots to the welding assembly floor as needed from the finished parts storage area in the Burning Shop. Under normal conditions the welding assembly schedule is planned to keep the Weld Shop busy and maintain an even flow of material through the machine shop.

The Weld Shop adjoins the Burning Shop and is serviced with one 30 and one 50-ton crane. The welding machines are mounted along the walls, leaving the floor entirely open for work. The shop is equipped with one power driven positioner which handles work up to 7000 lb. in weight and having the center of gravity not more than one foot from the base. In addition we have a 45 degree frame upon which large pieces are placed by the crane for down-hand welding. For automatic welding we have a wall type traveling crane and will weld over an area of 3000 square feet. The machine was designed for Unionmelt welding and is provided with rapid traverse speeds for rapid transfer from one job to another.

ASSEMBLY & WELDING PROCEDURE

The assembly for welding procedure that is used for the fabrication of the various press parts is carefully planned so that as much of the structure as possible may be "strung up" before any heavy welding is done. Through this procedure of putting a very light pass in each joint to be welded, it is possible to tie the structure together and reduce the distortion to a minimum. This procedure also facilitates the safe handling of the structure as the weld joints are positioned for welding with the so-called "fast" down-hand heavily coated electrodes.

The group of six prints show rather clearly the method used to assemble and weld a large double action crown. Figure 3 shows the first assembly of the bottom plate, the central stiffener plate and some of the internal ribbing. Figure 4 shows the same structure as additional stiffeners and vertical sheets have been assembled. This picture clearly illustrates the use of temporary spacer bars to maintain the proper spacing of the plate during welding. Figure 5 shows the same structure at an advanced assembly stage. Here you can see the set-

up man and welder tacking a plate in place. The apparent blurr or light spot in the center of the picture is the arc of a welder who is "stringing up" the structure so that it will hold its shape during welding and make it safe to turn the structure for positioning the welds. Figure 6 shows the structure turned into position for down-hand fillet welding. If you will look closely you can see the helmet heads of two operators in one of the crown compartments. Figure 7 shows the nearly completed crown standing up ended to facilitate the down-hand welding of the cross ribbing. Figure 8 shows the completely welded and stress relieved press crown being machined. As was stated in the first section of this paper, the crown is essentially a large gear box in which all the mechanism of the press is housed. The close tolerances that are necessary require accurate assembly and welding procedure.

For the construction of the large "I" beam sections that make up the load carrying members of the bed we have developed an application of the Unionmelt automatic welding process to the point where it is possible to construct heavy "I" beams with a web thickness of $1^1/_2$ inches without bevel preparation on the web. Figure 9 shows a photo macrograph of a typical joint in the "as-welded" condition. It illustrates clearly the overlap of the two welds and the complete elimination of any synthetic cracks. We have developed standard welding conditions for each web thickness and can make up these heavy "I" beam sections in almost any conceivable size.

CONCLUSION

We have briefly outlined the development of the welded steel press and have described the procedure used in welding these large structures. Welded design has enabled us to build a quality press, of greatly improved appearance, more quickly and more economically than by any other means of construction. We are confident that the combination of good welding design and the use of proper welding technique produces the most satisfactory type of press construction.

REPAIRS TO STEEL CASTINGS AND Other Steel Mill Parts*

By S. D. BAUMER†

WHEN we speak of maintenance welding and cutting in the steel mill today, it is not placed in the same position it was ten years ago.

At that time, we were more concerned in selling both the operating and repair organizations on welding and cutting as a process that would prevent the scrapping of many vital pieces of equipment than the correct way in which to perform the work.

Today I do not believe there is any industry in our country that appreciates more the correct use of welding, both as a time saver and of course a cost saver, than the modern steel mill, whether it be for a maintenance or a production problem.

For this reason, we have divided welding into three divisions or processes; thermit welding, electric arc welding and oxyacetylene welding, all of which are supplemented by cutting operations.

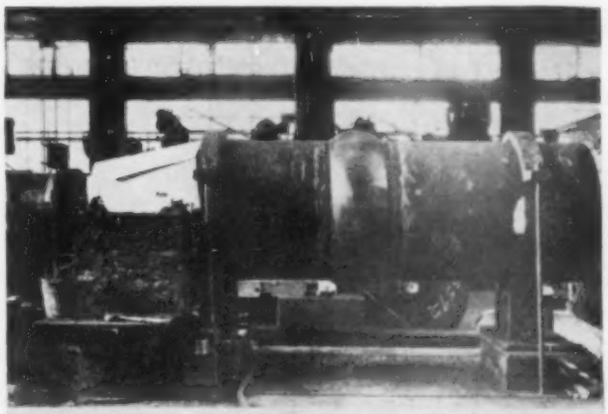
THERMIT WELDING

As an example of the thermit process, we will take a 36 inch diameter bending roll which was broken in fabricating a $^3/_4$ inch thick plate in the steel car production shops.

This particular piece of equipment was forty feet in length costing somewhere in the neighborhood of $10,000. The question was, could it be repaired successfully by the thermit process in a short length of time so that the shops would lose the minimum amount of production?

Inasmuch as the break was of a ragged nature, we decided to true up as little of each piece as possible in order to hold our welding gap to a minimum.

Fig. 1—Thermit Weld of 36 Inch Diam. Bending Roll Showing Wax Applied to Break



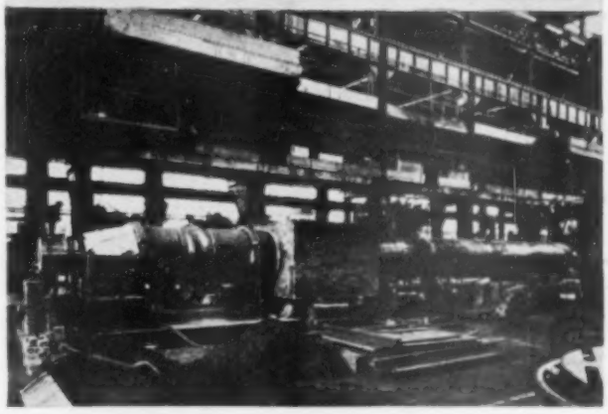


Fig. 2—Second Step of Thermit Weld Showing Check Heating Furnaces

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.

† Superintendent, Welding & Sheet Metal Work, Bethlehem Steel Co., Johnstown, Pa.

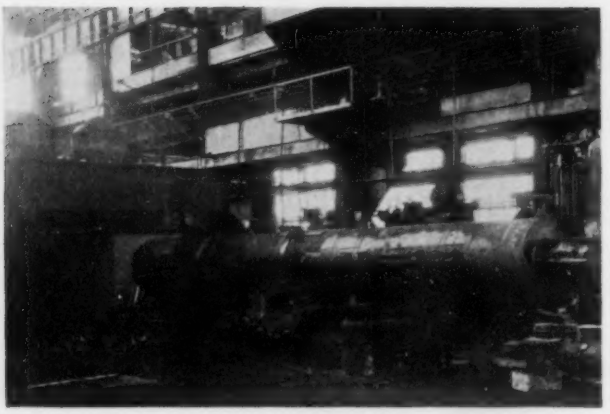


Fig. 3—Third View of Thermit Weld Showing Furnace and Pots

This part of the operation was done in a large engine lathe in the main machine shop building where the correct crane capacity was available.

After the machining operation was completed, the two pieces were lined up and leveled by means of specially made vee blocks and surface tables and you will note from the photographs that all the equipment used was somewhat heavier due to the size of the work.

The waxing of the joint was then started and during this period it was decided to build two extra furnaces, each to be located six feet from the proposed weld, so that the heating of the broken parts could be held in a confined area and also to facilitate the heating operation.

The next step was the actual molding operation. A special flask was built in sections so that the height could be increased as the molding progressed insuring a satisfactory ramming application of the thermit sand.

Following this operation, four burners were placed on opposite sides of the mold and the wax melted away from the joint. At this time actual preheating was begun with periodic checks made to determine alignment of the pieces and the tightness of the holding clamps. Heating time, which was done very slowly, actually required thirty hours before the pouring operation was accomplished, which only required several minutes time.

The mold was then left to cool without removing any part of the sand for thirty-six hours. On removal of the flask and the sand from the mold, the roll was found after a careful check to be out of actual alignment less than $^{3}/_{32}$ inch which could easily be taken care of by trueing up the roll journals.

The last and final steps were to first cut off the gates and risers of the mold which was done with the burning torch. The roll was then placed on special cast-iron bearing blocks in the large engine lathe and the excess weld metal and journals were turned to size.

The entire job when completed was accomplished in two weeks time and the cost was approximately 25% as much as a new roll which would have required at least two to three months for delivery and fortunately this roll has been in every-day service for the past four years with no sign of failure.

Although this type of welding today is not as frequently used in the steel mill as it was several years ago, it still has a wide range of application on the heavier type of repair, such as the one described and on broken mill pinion necks.

ELECTRIC ARC WELDING

Electric arc welding in the steel mill is possibly the most widely used and certainly one of the most essential tools employed in the repair and upkeep of the plant equipment. To attempt to describe its many applications is far beyond the time allotted to this review. However the work described is typical of its uses in a mill engaged in the production of plates, shapes, bars, wire and finished products of various types.

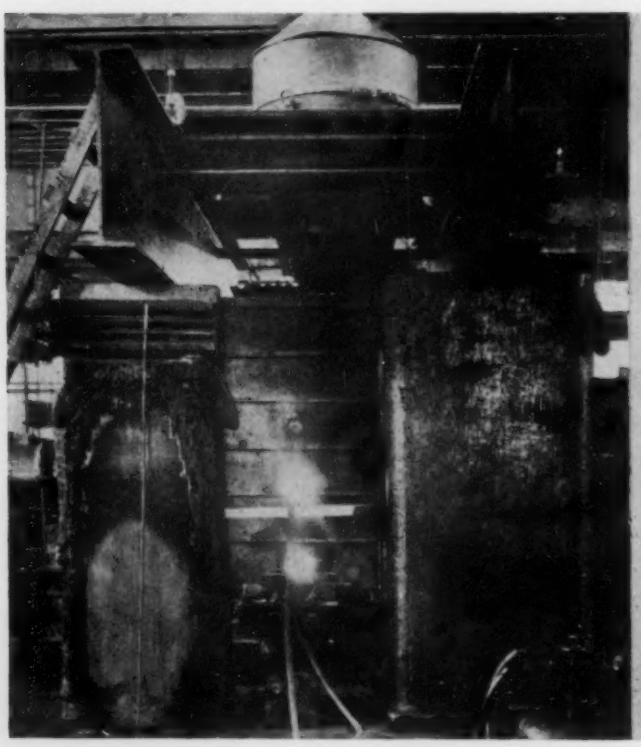


Fig. 4—Preheating Operation of Thermit Welding 36-Inch Roll

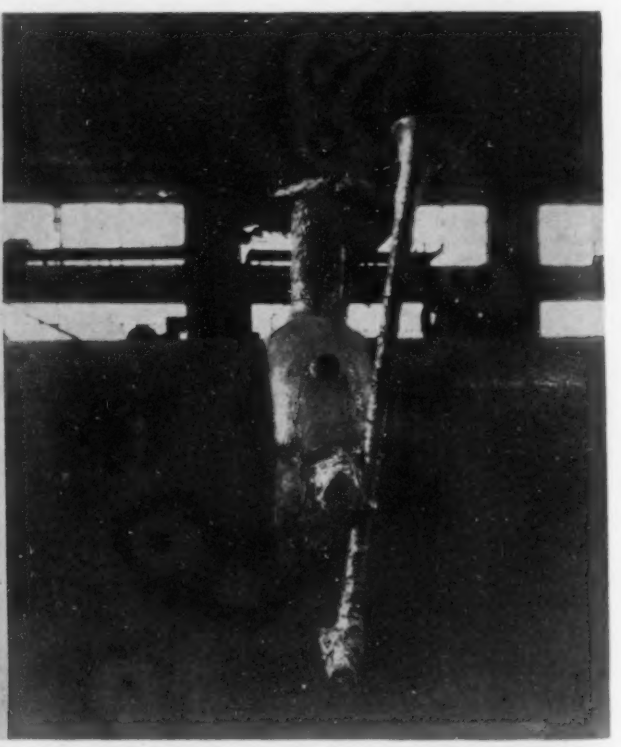


Fig. 5—Thermit Weld After Pouring Operation

Welding of this kind is scattered throughout the entire plant which is spread out over a five mile length and for this reason welding equipment has been placed at the most convenient locations where the operation may be carried on the most economically. It might also be mentioned at this time that all welding, regardless of the process or application, has been placed under direct supervision of the welding organization to insure the correct procedure for each individual type of repair, with all special jobs being performed in the main welding shop.

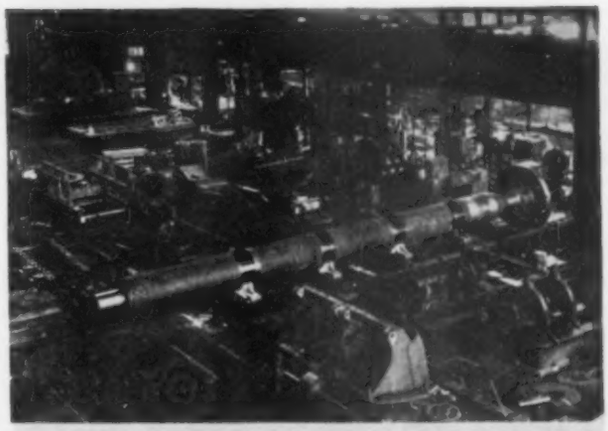
One of the many large uses for this method is of course the building up of worn parts which are being constantly reconditioned throughout the entire plant. In past years these parts were left to wear until they were either scrapped and renewed or were machined and then plated. Today they are welded and hard surfaced as soon as wear becomes apparent. A very good example of this procedure is the repair work done on all types of mill pinions, spindles and coupling boxes. This work is now performed without removing the worn parts from the mill and is done on a regular scheduled basis which has been worked out by the welding department and the mill master mechanics with the final decision directly up to the welding division. In this way thousands of dollars are saved each year by the avoidance of overly worn parts which require expensive preparation and an over supply of weld metal.

Another example of the time and money saved doing work in place was the failure of a large 40-inch blooming mill roll housing casting.

At the finish of a turn, on inspection, this housing was found to be cracked through from the bearing seat to the bottom web of the casting which was four inches in thickness. To remove this housing from the mill is a very costly job, so it was decided to attempt this repair in place. A $1^1/_2$-inch hole was drilled at either end of the crack to prevent further progress and the broken portion was then veed out with the cutting torch, ground and chipped to make sure all broken metal, scale and dirt was removed. The casting was then preheated to around 400 degrees and the welding started from the bottom upward, the weld being in a vertical position. Each successive layer of weld metal was lightly peened and cleaned to insure as solid a deposit as possible. After the main weld itself was completed, two braces from the bearing seat to the bottom web were welded in diagonally for additional strength. This work was completed in forty-eight hours time where it would have required four additional days to remove the housing, take it to the shop for reconditioning and then relocating and replacing it in the mill.

Still another good example of this process is the repair of a $3^1/_2$% nickel steel casting. This casting is used as a cylinder in a wheel press and works under 12,000-lb. pressure. This casting after some years service showed signs of leakage and upon removal was found to be cracked its entire length. Inasmuch as the wall thickness of this member was $11^1/_2$ inches, it was placed on a large slotter and a U cut from either side to form a double-U weld. The casting was then placed in the annealing furnace and stress relieved. After cleaning it was then preheated to 400 degrees and the welding started. From the beginning welding operations were carried on through three eight-hour shifts until completed, with each successive bead or layer peened and cleaned to insure a solid weld. The casting was again placed in the annealing furnace and stress relieved the second time before final machine operations were begun. Here again was a good example of time and money saved as this casting was quoted at $12,000 and would require many months to replace as patterns were not available. Actual repair costs only amounted to $3000.

Fig. 6—Roll in Process of Machining After Welding



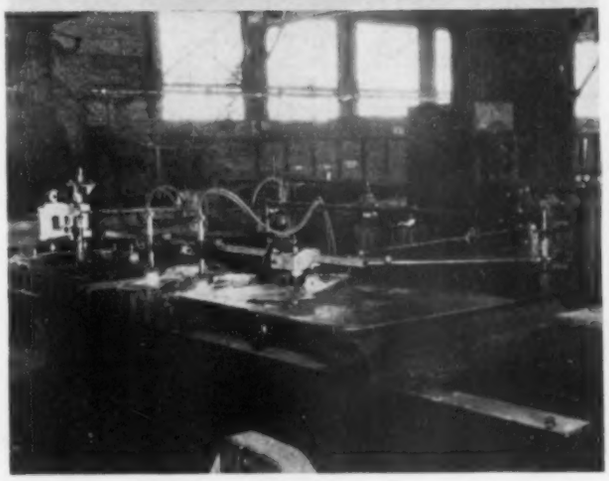


Fig. 7—Automatic Cutting on Maintenance Parts with Two Torches in Operation

Because of the frequency with which many other steel mill repairs are made by the electric arc method, such as the reconditioning of open-hearth doors and frames, gas and tar burners, tuyères and stripper bits, they are scheduled on a production basis and are handled daily by a crew of men experienced on this particular class of work and I might add that each line of work from the coke plant down along the line to the semi or finished department requires a different line of attack and a different knowledge of the type welding to be done.

OXYACETYLENE WELDING AND CUTTING

Oxyacetylene welding and cutting, which is probably the oldest of the three processes, still hold a place of vital importance in the repair of steel mill parts.

In this connection we may rightly assume that scarfing or deseaming is a steel mill repair. Not so many months ago practically all of this work of repairing or removing defects from steel was done with the chipping hammer. Today 90% of this work is done on the carbon steel grades with the scarfing torch which requires considerably less time, men, space and considerably less energy on the part of the operator. This application has grown so rapidly that it has become a problem to furnish operators fast enough to take care of the demand.

One of the most important steel mill repairs we have recently made is the reconditioning of the plate mill crane runway which is 625 feet long or 1250 feet for the entire length on both sides. It was decided to acetylene

weld all joints in order to eliminate any irregularities in the runway. All splice bars were also eliminated and rails 60 feet long were used in order to have as few welds made as possible. Rail ends were scarfed and ground and placed on the girders ready for welding. They were then preheated using two men for the preheating and welding operation, an alloy steel rod being used with standard railway joint practice. The welds when completed were immediately covered with asbestos and left to cool slowly for three hours, when they were uncovered and ground to size. The whole job including the removal of defective rails required seventy-two hours to complete and has proved itself to be the most satisfactory repair runway in the plant especially from a crane maintenance standpoint.

Another wide use of this process is the bronze-welding of numerous worn and broken iron castings. For example, over a period of years, we have been applying manganese bronze to the bottom half of all cast-iron mill engine piston heads. We find that by this application the piston head itself takes the majority of the wear and therefore saves the reboring of the cylinder walls. By a close check and follow up, it has been developed when to remove these heads from the engine for an additional application.

In addition to the above, a general use for this type of work is the repair of locomotive cylinders broken in service. In the past these parts were generally removed from the locomotive proper which was always a costly proposition. Now a brick furnace is built around the cylinder in place, the cracks veed out and heated as it stands. Bronze-welding is then completed and the cylinder allowed to cool slowly in the furnace. Seventeen of these welds have been made successfully and are in running order today.

Oxyacetylene is also used on many other types of work such as the hard surfacing of mill guides, trimmer blades, pusher shoes and a great variety of small wearing parts throughout all departments.

Supplementing all the above work of course is the automatic and handcutting torch and the oxygen lance without which it would be difficult for the modern steel mill to be without. Its application is so widely used that it would be impossible to describe at this time.

In summing up all the above, which has only touched the surface of steel mill maintenance, I might say that welding has found a very definite and decisive place for itself in this line of work which cannot be replaced by other methods.

OXYACETYLENE WELDING

Red Brass Pipe*

By ARTHUR N. KUGLER†

INTRODUCTION

THE remarkable success of the application of the welding processes to the field of piping fabrication is a story well known to all. Present-day high pressure, high temperature piping systems would be impossible of realization were it not for fusion welding and the far-reaching changes it has wrought in this art. This success in the field of steel piping has naturally prompted engineers to investigate the suitability of these processes for other metals with the result that today we find welded piping systems of aluminum, copper, monel, nickel, stainless steel and brass. All of these new ventures carry with them the necessity of careful investigation of the welding peculiarities of the metal involved, and this research continues, for herein lie new fields for welding to conquer.

Red brass, consisting of 80 to 85 per cent copper and 20 to 15 per cent zinc, is one of these more frequently encountered analyses of pipe metal. This analysis of brass is used extensively in conditions where corrosion is particularly bad. In certain types of hard water it has been found that yellow brass (copper 67 per cent, zinc 33 per cent) is eaten out in the relatively short time of about ten years whereas red brass appears to last almost indefinitely. This may be attributed, in part at least, to the higher copper content. The following typical examples of service conditions under which red brass is successfully operating further emphasizes the value of this metal: (*a*) boiler feed lines and steam return lines in which high concentrations of boiler compounds exist, is a particularly severe test; (*b*) domestic hot water systems, operating at temperatures of 120–150° F., especially at extensive hospital and sanitarium plants, where failure might jeopardize the lives of patients; (*c*) rain conductors, encased in masonry, and passing through many floors of buildings where leakage would cause costly damage.

These severe service conditions to which red brass pipe is subjected indicate the necessity of joints capable of rendering equally satisfactory performance. Coupled with this is the fact that much of this pipe is buried underground in conduits where failure of a joint would involve a costly repair job to say nothing of temporarily disfiguring the landscape. It is quite logical, therefore, that the welding process should be looked on with favor and specified by engineers designing systems of these types.

EARLY INSTALLATIONS

Welded red brass piping systems are not new. There are many which have been in service for over ten years giving a thoroughly satisfactory account of themselves. Among the earliest installations was a boiler-feed system installed in the power plant associated with a group of docks in Metropolitan New York. This piping erected about fifteen years ago was not of solid welded construction but rather a modification of the then accepted practice. Standard lengths of pipe were welded to high hub welding neck flanges (cast brass) and these assemblies bolted together or to fittings. After about ten years of service we were called in to determine the cause of a leak at one joint. The pipe size involved was eight inch,

* To be presented at Annual Meeting A. W. S., Chicago, Ill., Oct. 23 to 27, 1939.

† Mechanical Engineer, Air Reduction Sales Company, New York, N. Y.

Fig. 1—Painting Flux on Beveled Pipe Ends

Fig. 2—Fluxing Rods in a Typical Field Container for Flux

Fig. 3—Flame Adjustment—Neutral

standard weight. The joint, after removal from the line, was placed over a forge fire and heated to a dull red, and the old weld melted out with a torch. In removing the old weld careful observation failed to disclose any defects. On rewelding this joint, however, a large amount of porosity was discovered in the cast brass flange and it was quite evident that the leakage was through this porosity.

Another early installation of note was at a large county hospital in New York State in which all of the domestic hot water lines from two inches to eight inches were welded. Installed about ten years ago it has given thoroughly satisfactory service and no leaks or other troubles have been reported. A somewhat more recent installation, about five or six years ago, involved two-inch to four-inch pipe for ink solvent lines for a large four-color printing plant. Here the low flash point of the solvent required joints of assured permanent tightness.

All of these early jobs were accomplished with the dry fluxes and standard braze welding rods. The tensile strength of such welds was relatively low, rarely exceeding that of the base metal. These welds, while not seriously lacking in ductility, still had room for improvement. The density of welds made with dry fluxes is perhaps the most serious weakness, and doubtless this deficiency is reflected in the other properties.

FLUXES

The essential function of fluxes is to combine with, or otherwise render harmless, those products of the welding operation which will reduce the physical properties of the deposited metal or make the welding operation difficult or impossible. Since welding may be defined as being the intimate (intermolecular) union of two metals, with one or both of the metals being in a liquid or plastic state, it follows that only when this intimate union is prevented, by some substance foreign to good weld metal, is it necessary to provide flux. The oxygen of the air combining with the molten metal provides one of the chief sources of substances which the flux must remove. Brasses and bronzes do not oxidize in a continuous film as does aluminum, but rather in an intermittent manner which permits the formation of porosity as the molten bronze and base metal flow together. This property materially slows up the progress of welding and the operator in an attempt to rid the puddle of these gas inclusions tends to overheat the metal.

The melting point of a proper flux should be such that it starts at the point where the base metal begins to oxidize and it should remain fluid throughout a range covering the welding operation. This latter function may represent a temperature several hundred degrees above the melting point of the filler metal. If the flux fulfils these requirements it affords both the molten base and filler metals the maximum protection.

Investigation and research directed toward improvement of the braze welding processes soon disclosed that the difficulties lay not with the various rods but the fluxes. Accordingly efforts were directed to the improvement of fluxes with the result that a liquid or semi-paste formula was developed which yields welds of the highest physical properties yet obtained. These physical properties equal and in most instances exceed those of the base metal. A most important property of this new flux aside from the improvement in weld quality is the virtual elimination of fumes.

FLUX APPLICATION

The successful application of this new flux requires no radically new welding technique, hence available welding operators may use it, with assurance of satisfactory welds right from the start. Extensive laboratory and field tests indicate that best results are obtained if the flux is applied to both rod and base metal. The application to the pipe is brushing on, an operation requiring but a moment. This step is illustrated in Fig. 1.

The fluxing of the rods is best accomplished by dipping them in a copper or brass container 18–20 inches long, into which the flux has been poured (see Fig. 2).

These flux containers for the job may be readily fabricated of odd lengths of $1^1/_2$-inch copper or brass tubing by closing one end with welding and welding on either tripod legs or a flat plate base. The container should also be provided with a stirring rod for mixing the flux after it has been standing. This is made of a welding rod to which has been welded a disk of copper or brass of a size that will readily pass up and down the tube. In operation six or eight rods are placed in the container by the helper who raises them up and down in the flux several times, to coat them evenly. One or two rods are withdrawn from the flux and allowed to air-dry for a few moments before being used in welding. As the welding operator uses rods, more are added to container, by the helper. The operator uses only the flux-coated lengths of the rods and temporarily discards the uncoated ends. Later, at a convenient time in the operations, the helper or the welding operator tacks these discarded, uncoated ends together thus forming lengths suitable for coating and reducing waste to a minimum.

A most important advantage resulting from this

method of flux application is that a more uniform and adequate distribution is obtained than is ever possible with dipping the hot rod end in powdered flux. It also yields higher welding speeds in that it reduces the number of round trips to the flux can. This is further reflected in improved weld density as we shall see later.

WELDING TECHNIQUE

The actual welding technique is very similar to that employed in welding steel pipe except for the obvious differences in these metals. A standard braze welding rod is used. The welding tip should be of a somewhat larger size than would be employed on steel pipe of the same weight due to the greater heat conductivity of the brass. The torch flame is adjusted to a strictly neutral condition as illustrated in Fig. 3. The fluxed, beveled ends are next tacked with a sufficient number of tacks, approximately half the thickness of the pipe wall, to maintain them in proper alignment and relative position, shown in Fig. 4. The welding may be either forehand or backhand as the position of the joint and neighboring obstacles dictates expedient. Usually the forehand technique is preferred on rolling welds and horizontal pipe position welds. The backhand procedure, since it lends itself more readily to the control of the metal, is generally used for vertical pipe position welds. Figures 5, 6 and 7 show, respectively, the welding of horizontal pipe rolling welds, horizontal pipe position welds and vertical pipe position welds.

JOINT PREPARATION

The preferred bevel preparation and joint design for red brass pipe welding comprehends a 45° bevel with a land or shoulder of $^1/_{16}$ inch, thus forming the familiar 90° vee. Pipe delivered from the mill can be provided with this end preparation. If it is necessary to prepare short lengths in the field, cutting and beveling by machine tools is preferred. Where these are not available standard pipe cutters, hand or power operated, may be used and the desired bevel obtained with a coarse file. Wrought red brass welding fittings such as elbows, tees, flanges,

Fig. 4—Tacking Pipe

Fig. 5—Horizontal Pipe—Rolling Weld

Fig. 6—Horizontal Pipe—Position Weld

Fig. 7—Vertical Pipe—Position Weld

reducers, caps, etc., are available as standard items. A word of caution is in order at this point. Never attempt to mix red brass with yellow brass in a welded system as the difference in melting points renders it exceedingly difficult to secure reliable results. Since fittings are generally available in red brass analysis, the same type of pipe should be used with them.

PHYSICAL PROPERTIES

Bronze welds made with the new liquid flux, when subjected to the standard tests, show greatly improved physical properties. Reduced section tensile tests develop higher tensile and bond strengths in welds made with liquid flux than those made with dry powdered fluxes. The density of the deposited metal is much improved by control of the volatilization of the zinc. This improvement in density is reflected not only in increased tensile strength but also in improved ductility. Welds made in all positions, with this procedure, will successfully pass the "guided bend test," bending 180° on both face and root bends. This is one of the severest tests for ductility and the fact that these welds pass it is conclusive proof of the quality of the deposited metal. Still another test which confirms the improvement in weld quality is the all-weld metal tensile test specimen. The ultimate tensile strength of 0.250-inch diameter specimens from welds made with dry fluxes ranges from 38,000 to 49,000 psi. This should be compared with similar specimens from liquid flux welds which show a range of 56,000–59,000 psi. The corresponding elongations (measured in one inch) indicate a range of 8 to 22 per cent for dry flux welds compared to 22–39 per cent for liquid flux welds. The respective reductions in area are 26–28 per cent and 24–41 per cent. The Brinell hardness (500 kg.—10 mm.—60 sec.) of deposited metal shows 61 to 82 for the standard dry flux welds contrasted to 83 to 93 for welds deposited with liquid flux.

FLUX COATED RODS

A continuation of the original research project which gave the liquid flux has resulted in the development of a method of applying this flux to bronze rods as a permanent dry coating. This flux coating is extremely adherent, withstanding handling in shipment and permitting of bending the rod in the usual manner to facilitate welding in the various positions. The quality of welds made with the new flux-coated rods approaches those made with liquid flux and are definitely superior to those made with dry fluxes. The relative merits of braze welds made with the various types of fluxes may be enumerated as follows:

1. Liquid flux on base metal and welding rods.
2. Coated rods with liquid flux on base metal.
3. Liquid flux on rods alone.
4. Coated rods alone.
5. Dry fluxes.

RECENT JOBS

The manifold advantages of this liquid flux, as demonstrated in the laboratory work, have been fully confirmed both in field trials and on actual construction work. One of the earliest applications of this procedure was on plumbing and rain conductor pipes (of red brass) in a large alteration job in New York City. The work was under strict government inspection and all operators were required to pass qualification tests similar to those required on steel pipe welding. Union welders were employed and no difficulty was experienced in coaching these men in handling this flux. After a brief period of instruction they were able to pass the required tests. Pipe sizes on this work range from 2 inch standard weight up to 12 x $^1/_2$ in. wall pipe. Welds were made in all positions with all manner of obstructions to make it more difficult. In spite of these handicaps welding proceeded rapidly and economically. Of especial importance on this construction was the extremely low fuming properties of the flux. Much of the work on the large heavy pipe was performed on a gallery, between floors, with an actual clearance of but five to six feet and very poor natural ventilation. In spite of these obviously poor conditions no operator was affected by the fumes.

Another outstanding installation of much larger magnitude is still under construction. This is an extensive central heating plant with welded steel distribution mains running underground in conduit to the various units of the project. Since all the outside piping is buried underground and will be accessible only by digging it up, the mechanical consultant decided to specify welded red brass pipe and fittings for all steam return lines. The welding operators were subjected to rigid qualification tests administered by an insurance company. Qualifying welds made in all positions were given the guided bend test, both face and root. Two union steam fitter welders were qualified for this project and have successfully carried out all of the work.

Due to the large size of this job the contractor planned his work so that much of the welding and fabrication was performed in the shop and trucked to the job. Thus all expansion loops and other complicated assemblies were shop fabricated by welding and bending and naturally a large part of the field work was position welding. No difficulties have been encountered in this work either in the field or shop, and tests of the completed sections show thoroughly satisfactory work.

CONCLUSION

The success of these and other similar projects indicates that braze welding red brass pipe with standard rods and liquid flux offers these definite advantages:

1. Greatly improved strength and ductility of welding metal.
2. Greatly improved weld density and hardness.
3. Speeding up welding by approximately 25% with consequent lowering of costs.
4. Simplification of technique, thereby assuring that average operators can handle the process.

In conclusion, it is interesting to note that this same liquid flux, with the higher strength bronze rods, will yield braze welds of tensile strengths as high as 71,000 psi and ductilities which permit of satisfactory face and root bends in the guided bend test jig, on steel and galvanized iron. Of especial interest is the welding of galvanized pipe by this procedure. By coating galvanized surfaces for 3 to 4 inches on each side of the weld the galvanizing is preserved intact during the braze welding. The deposited bronze flows up to and overlaps the zinc, producing an assembly that is corrosion resistant.

PRESENT DAY PRACTICE IN Structural Welding*

By ALEXANDER L. WILSON†

AS BEING the most likely to be practical and helpful I am going to take the work in our shop on the twenty-fourth of June and outline its production as carried out at our plant.

First let me give you a brief outline of the organization of our shop. We have four departments: stock, punch and rivet, welding, and painting and shipping. Most of the miscellaneous work is included in the welding department as the bulk of odd structures are welded today. This includes plate rolls, angle rolls, blacksmith and bulldozer. To handle the material between departments we have one man who serves the whole shop.

A certain amount of time is required by each man who works on a piece to study the drawings and familiarize himself with the job; aside from the actual mechanics of changing tickets, moving tools and so forth. We try to let one man handle as much of a job himself as possible.

In this connection I might say that each leader has his own toolbox with a standard list of tools which he keeps with him, saving time in getting and returning tools to the tool room.

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.

† General Foreman, Mississippi Valley Structural Steel Co., Melrose Park, Ill.

WELDED TRUSSES

Figure 1 shows our truss floor. This is made out of heavy H-sections placed about four feet apart. In building trusses the outline of the truss is laid out on the floor. At the right in the picture you will note the clips tacked on to clamp the truss members to. Clips are also provided to locate the web members exactly.

The trusses shown are heavier than our general run of welded trusses. They are fifty-five feet long and have a double angle web system. The top chord is bent in three places. In preparing to build these trusses the top chords are laid in the center, marked and notches burnt out for the bends. The bottom chord angles are laid on the floor at the right and the web members placed between the skid beams.

The top chord is heated at the bend points and bent around the clips of the jig. In the case of curved chord trusses we tack the top chords together before bending them and after that they are handled as one unit.

At the center right of the picture you can see a couple of web members laid in. As they lap on the bottom chord and had to be welded before their mates could be assembled we had a welder working with the fit-up gang.

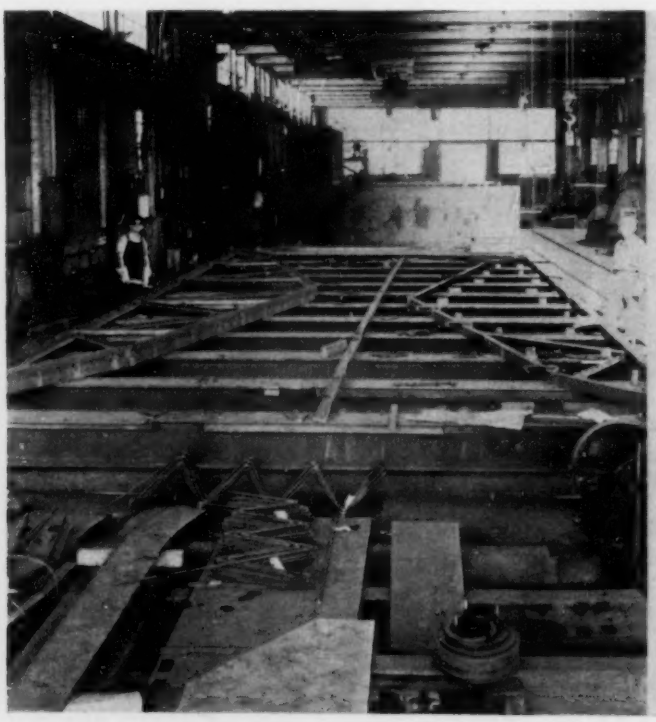


Fig. 1—Truss Floor

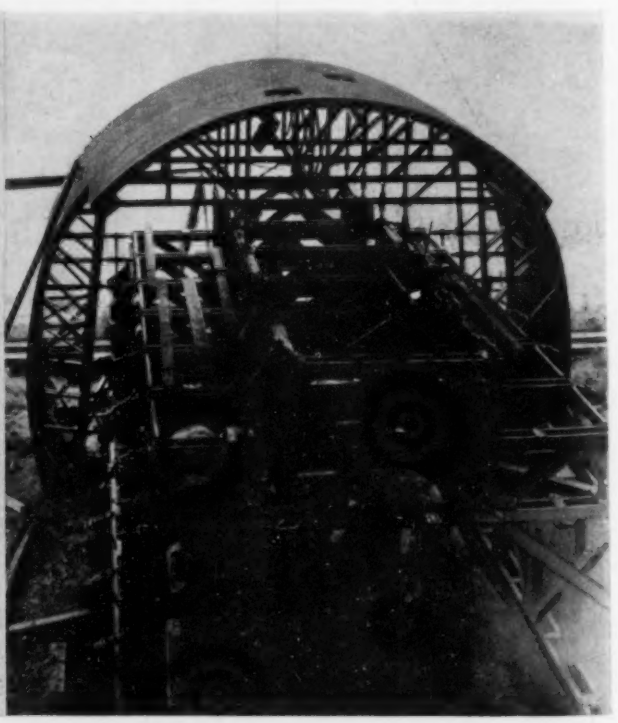


Fig. 2—Concrete Tunnel Forms

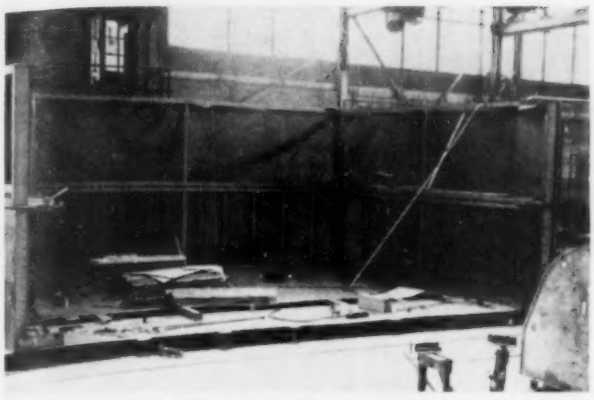


Fig. 3—Flat Floor Required for Assembling Skin Plates for Concrete Form

After the truss is assembled and tacked it is turned over and the welder completes it while the fit-up gang is assembling another one.

Trusses have been welded using various sections for chords. I believe the largest ones that we ever built were ninety feet long and eight feet deep, using seventeen inches of a twenty-four-inch beam for the top chord and the other seven inches for the bottom chord.

When using split beams for chords and notching them out at the points where the chord changes direction you will probably find it necessary to heat the side of the web that is welded first just prior to welding the back side of the joint. Otherwise the first side welded makes the joint so stiff that when the back side is welded and cools the weld cracks. If a splice plate is placed across the joint we have found it better to weld parallel to the member being spliced instead of transverse to it.

There are certain definite savings in welding trusses which you are probably all familiar with; namely, the reduction in the size of the tension members and the reduced cost of welding wire over rivets as a connecting medium. In building trusses with camber in them especially if built in two halves we have found it decidedly easier to build camber into welded trusses.

When debating the matter of welding trusses there are certain variable factors upon which the decision rests.

A. The proportion of weight saved by eliminating gusset plates. The larger the trusses are the less the saving in this respect.

B. The labor required to handle and hold in place the members for welding increases with the size.

C. The laying out and building of a jig for a set of trusses remain constant. Therefore the unit cost increases as the number of trusses decreases.

CONCRETE TUNNEL FORMS

Figure 2 shows two out of six bands of outside sheeting assembled. This is the form used in pouring concrete on a highway tunnel project in Seattle. The form itself is about twenty-five feet high and thirty feet wide. To support the forms properly there is a heavy riveted frame which runs on eighty-pound rails. The forms are hung from this frame on jacks.

In operation the whole machine is moved ahead thirty-two feet, its length; the forms raised by means of the top jacks and the sides swung out by means of two series of jacks on each side. The concrete is then poured under pressure through a group of doors in the form sheeting. After setting the sides are jacked in, the top lowered and the process repeated.

The outside sheeting is quarter-inch plates sixty-four inches wide, each welded to two supporting trusses. The outside is made up of eighteen sections each built independently of the others. There are really three major problems to be solved in the construction of this machine.

1. To make each of these sections so accurately that when they are assembled the edges will match exactly so that concrete under pressure will not leak through them and the edge of one section will not be higher than the edge of the adjoining section leaving lines in the tunnel wall that have to be smoothed off.

2. There are three different radii in the bent angles of the side trusses adding considerably to the difficulty of making these angles all exactly alike.

3. The doors which occur in the sheeting to permit the pouring of the concrete must have as small a clearance as possible and be in the same plane as the rest of the sheeting when finished.

The first step in the solution to the first problem was to have the plates planed to size. Other steps will be described as we proceed.

All angles on the job were first tack welded together in pairs and bent to the proper radius in a bulldozer. Then the angles were cut apart, ground up and each angle laid on a full-sized layout scribed on a plate. They were brought on to this line either by bending a little more or hammering the bend out by pounding the toe of the horizontal leg. It is really remarkable what you can accomplish in changing the bend of an angle by hammering the horizontal leg.

The trusses were first built in the usual manner except that after the first one was tacked up in the jig, the mate to it was built right on it so that every point along the back of the pair of trusses would be the same. The gussets containing the pinholes were assembled over pins welded to the floor, making the distance between pinholes the same in all cases.

Fig. 4—Main Assembly Jig for Welding Car Frames

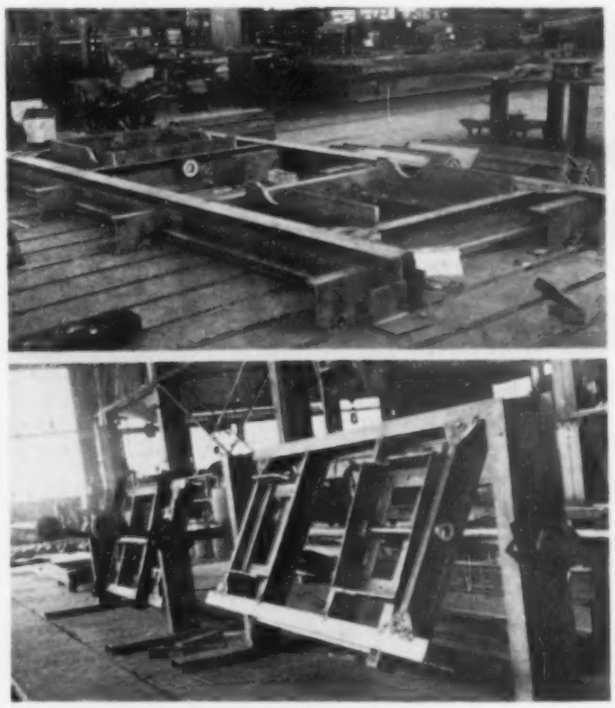


Fig. 5—Jigs for Positioning Frames for Welding

Before assembling the trusses and skin plates for the top sections the welding floor was checked with a transit to assure that the pin plates would be worked off a plane and not a warped surface.

Might I disgress here to say that one of our most valued tools in the welding department is a surveyor's transit. It is very hard to build structures plumb and level if the base you work on is not right to begin with. We find a transit much simpler than trying to level large surfaces or a number of beams for a temporary floor with a straight edge and carpenter's level.

Four clips with drilled holes were located and tacked to locate the pinholes at the ends of the trusses. Then one rod was run through both trusses and both clips at each end of the top form section. Please note that one rod was used for the connection of the two side trusses to the jig angles. It is very hard to get good alignment with short pins. When possible use a long rod and run it through all holes you want in line. The trusses were held apart with double nutted rods and the skin plate tacked over the top of them. Special care was taken to see that the plate was worked from the center line toward the two ends of the trusses. The distance from the four corners of the plate to the welding floor was checked each time to assure alignment of these horizontal joints in the finished machine. The bracing in these sections was tacked in and the rods taken out. It is worthy of note that none of the final welding was done until considerably later. This was intentional so there would be no chance of warping from welding until the final assembly. The stiffeners were also left out at this time between the trusses and against the plate for the same reason.

As it was deemed impossible to make both the top and side sections accurate within a few hundredths of an inch the side trusses were framed together, using the same clips and rod for lining the pinholes in the connection plates, but leaving off the skin plate on the back of the trusses.

In order to assure that all the milled edges of the plates in the form would match, the final assembly of the sections was made in the relative position in which the pieces would be in the finished structure.

Figure 3 required a flat floor thirty by twenty-two feet. As none of our welding floors is this large, it required laying in a new floor using eight-inch beams to get head room covered with quarter-inch plates sufficiently to permit laying out a complete cross section of the form. This floor was shimmed flat within a thirty-second of an inch.

A top section of the form was placed with the skin plate edge on the scribed line and properly centered. The side sections were set in and joined to the top by placing one of the pins through the pin plates of the two sections. The side skin plate was then set against the end of the top skin plate and the bottom of the plate as shown in the picture forced against the truss by means of wedges worked against clips tacked to the floor. The top edge was clamped and tacked.

Another band of three sections was then assembled on top of these. The skin plates were brought flush at the joints by using nuts and drift pin clamps.

These are very economical and handy clamping devises for this work. You merely weld a nut to the low plate. Cut out a small plate with a hole in the middle sufficiently large to clear the nut. Place it over the nut and across the joint in your two main plates. By driving a drift pin through the nut on top of the small plate you force down the high plate and pull up the low plate, at the same time giving a flush joint.

Between the chords of the sections we had a space of an inch and an eighth which permitted reaching in and

Fig. 6—Struts and Columns for Power Station

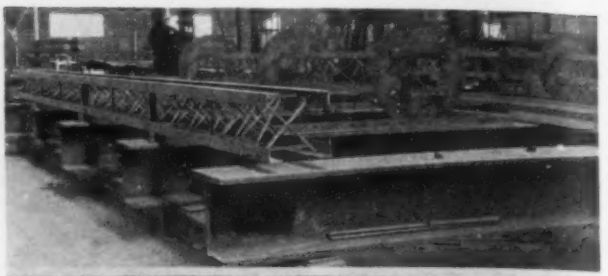


Fig. 7—Flood Light Towers

tacking the bottom of the skin plate of the top side sections to its truss. This was a difficult operation and required close supervision as the final matching of the edges required that these be well tacked at this time.

At this point the stiffeners against the skin plate were put in place and a considerable amount of welding done to the whole structure to assure that when completely welded it would not change shape.

The top three sections were then taken off and set aside and the bottom three sent to the yard where the rest of the work was done on them. The sections that were on top were then set on the layout on the bottom and three more sections assembled on top of them. In like manner the work was carried forward until all eighteen sections of the form had been assembled in this manner.

We now follow our sections to the yard. The main operation here was the cutting and building of the doors for pouring the concrete. These were laid out and burned with a double-ought tip. At first we burned about six inches and tacked a bar across the joint to maintain alignment until the door frame could be built inside. As the flange of the channel of this frame straddled the cut the frame could not be built first. This did not prove satisfactory. The burner suggested that he leave about an eighth of an inch of metal every few inches and blow this out after the door frame was built. This was found to be very satisfactory.

We found the channels had to be fitted very carefully to the curve of the skin plate, and although we lined the hinge plates up with a rod we were not able to maintain perfect alignment of the doors after welding. We found it very helpful to weld everything possible before the door was cut free. After the door was completed we wedged it tightly into place and reamed the hinge holes to seven-eighths and put seven-eighths bolts in them. This was found to give a very satisfactory door even with the small clearance we had around the door plate.

After the sections were welded they were assembled on the supporting frame as shown in the first picture and the only thing found necessary was to run a flatter over the joints for a few feet here and there to make the whole outside shell flush.

FORTY CAR FRAMES

These are small cars about nine by four feet used to carry railroad ties at a creosoting plant.

Figure 4 shows the main assembly jig. The semicircular notches in the angles fit the castings on the axle housing. In order to get a satisfactory fit on these the ends of the angles were milled. A jig was then built and a pair of angles was burned out with an automatic circle burner, the location of the cuts being gaged from the milled end and the back of the angles. The bevel cuts at the toe of the angle fit an ear on the housing. This was burned from a cardboard template free hand. The first three or four were tried on the housing and the templates adjusted slightly until a full bearing was obtained all around.

The assembly that holds the axle I shall refer to as a truck. You will notice that the truck at the right end of the picture is built directly into the frame and the one at the left end is assembled on a cold-rolled pin the end of which you can see in the picture. The reason for this is that the cars will be used on an industrial track laid on the ground without leveling. By having the left-hand truck rotate in this manner all four wheels will ride on the track no matter how irregular the elevation of the track.

Both these trucks were assembled in jigs made by tacking angles to the welding floor. The jig shown for the main assembly was then built. You will notice that the channels lining up the I-beam sills are all on the near side of the beams. By driving wooden wedges in the far side the beams were held in place and by knocking the wedges out the frame could be slipped away and lifted from the jig.

The next thing that became obvious was that in order to reach all points on these cars for welding they had to be handled a great many times with a crane, thus increasing the welding time and tying up the cranes.

We have no universal welding tables for as a general rule we have only one or two pieces of a kind and the time required to adapt a table for each piece is too great. In Fig. 5 we have two jigs for holding these frames that are very simple and efficient. They consist of a couple of channels laid on the floor with an I-beam tacked to them in a vertical position. Through the top of the beam a two-inch gas pipe is run with angles welded across it to support the car frame. In the far jig you can see the bars with a chunk of scrap metal welded on to counterbalance the weight of the car frame. In this manner the frames could be rotated by one hand and would remain stationary in any position in which they were placed.

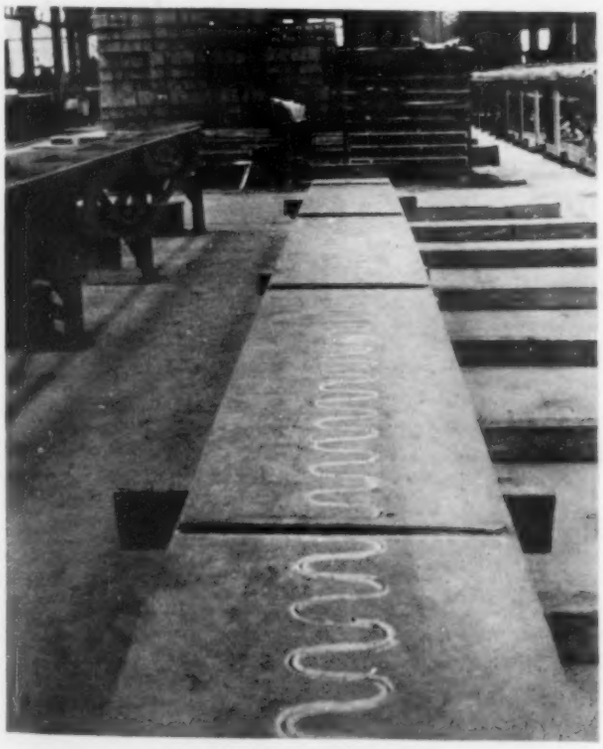


Fig. 8—Highway Expansion Joints

LACED STRUTS AND COLUMNS

The struts and columns, in Fig. 6 are to be used at a power station in Hudsonville, Ill. The conventional type of construction is a combination of H-beams and I-beams.

A finished piece can be seen in the foreground. It is made of four angles with bent half-inch bars joining the diagonally opposite angles. At the points where these bars cross they are tacked together and about an inch of weld placed where the bars join the angles.

Before detailing the job a full size piece a foot square and twenty-five feet long was built and tested under full load. This required vertical loads equal to the weight of the equipment together with a uniform load equal to the weight of the snow and ice that might come on the structure. Three horizontal loads equal to the pull of the cables leading into the substation were added. After the loads had been applied they were removed and the piece regained its original shape. The load was then doubled and applied with no sign of failure.

In the production of these pieces we have two definite problems.

1. The bars have to be bent very accurately as regards degree of bend and distance between bends.
2. The welding of the piece requires a great deal of rotation of the piece to reach all points to be welded.

At the time of the Century of Progress we built the Crystal House which had columns with one-inch square bent bars laced between channels. These were bent by machine but in the end had to be heated and brought into exact position before welding. Accordingly on this job we heated the half-inch round rods at the bend points as we laced them about a series of pins welded to the top of a heavy wide-flanged beam. This gives you the complete rod bent into the final position in which it will be used with all points touching the angles in the correct relation. When assembling there is no necessity of pulling or twisting the rods to bring them to the required position. The bent rods are made in sections varying from six to nine feet.

About every three feet these struts have a square frame of half-inch square rods. These rods could have been cut on a shear but were sawed so that by bringing the angles down against the end of the rods they acted to square the frame. These squaring frames were first built in an independent jib before being placed in the strut.

It has been our experience that trying to weld material that is not perfectly cut when a square and plumb job is required is foolish economy. When you have a corner here or a flange there that does not bear, the weld metal has an excellent opportunity to draw the piece out of shape and cause trouble.

In the background you can observe the means used to hold these pieces in line and also to turn them without

changing the alignment. A square hole was cut in the center of three circular plates and a series of holes drilled around their circumference. These roll between two angles tacked to the welding floor. By driving pins through the holes in the angles and in the circular plates the alignment of the whole piece can be maintained while it is rolled over for welding. The plates are split in two so that when the welding is finished the top half may be lifted off and the finished piece removed. This worked excellently where the plates were, but in between the angles tended to spread. To overcome this difficulty we welded some small clips to short angles with the clips facing each other and twelve inches apart. By driving four of these clamps onto the strut at such points as seemed to be out of square the alignment was maintained in good shape. One of these intermediate clamps can be seen in the background.

In spite of all the care taken with these there were some slight twists between points where the rods joined the angles. After galvanizing we found the heat had released this strain and the pieces were in good shape.

FLOOD LIGHT TOWERS

Figure 7 shows a group of five flood light towers completed and awaiting shipment. They are sixty-five feet high and about ten feet on a side at the bottom. This seems to be a very easy way to build these. The angles are closed from ninety to sixty degrees. One side is built in the same manner as the trusses described at the beginning of the paper. By raising the first side and using the bottom chord the second side is built in the same manner. It is rotated through sixty degrees again and the lacing placed across the third side. These particular towers were built in three sections with milled ends. After each section was finished in the shop they were taken out in the yard and assembled into the completed tower to save room in the welding department.

HIGHWAY EXPANSION JOINTS

These plates shown in Fig. 8 are about twenty inches by an inch and a half. The first problem is to burn out teeth. For this we used an automatic that has a magnetized roller which follows a steel template. We use a nine-inch channel for the track for the burning machine. It cuts about seven teeth and then the machine is moved along and clamped to the plate and another series of teeth are cut.

To reduce warping in the plate we follow the torch with a stream of water. After a few feet of teeth have been cut we tack a bar across the cut to hold the two plates in position until the rest of the assembly is made.

The plates are fastened to the bridge by means of pedestals made out of half a beam with two angles welded to the tongue. These pedestals vary in height which determines the crown in the expansion joint.

We have found that by building these joints bottom up with the ends of the plate blocked up to give the required crown the welding of the pedestal furnishes enough draw to hold the crown in the finished piece.

The last group, however, had about three times the welding on it that it required but as it was a government design it had to go on. This required peening as the welds were made to reduce the shrinkage caused by cooling. We have found peening very helpful when done within a few minutes of the time the weld is laid down, but have had no success when the peening was delayed until the following day.

Fig. 9—Spiral Scrapers

Fig. 10—Bulkheads for Air Lock

That brings up an important factor in the training of your welders. When a weld cools it shrinks. The present coated rod shrinks a great deal more than the old style bare rod due to the increased heat used. This can in various cases be made to work to advantage. One weld can be made to counteract the distortion of another to a greater or less degree. It is not possible to tell exactly where a given piece is going to go. When you have different assemblies going through the shop at the same time it is hardly possible for the foreman to watch all of them. It then becomes necessary to have your welders trained to at least observe what is happening to the piece they are working on and if they cannot avoid distorting it call the matter to the attention of someone else so that as much distortion as possible may be avoided.

Some of the standard methods of controlling this distortion all of which are helpful are:

1. Back stepping of welds.
2. Light tacking of pieces together so that as one expands faster than the other the tacks will break and the stress will not be locked up causing distortion.
3. Use of water on thin sheets while welding to confine the strain to a small area and thus prevent buckling.
4. Making of welds on the far side of a plate beam or channel before the weld on the near side gets a chance to cool, so that the whole mass of metal cools together.

SPIRAL SCRAPERS

The job in Fig. 9 has comparatively little welding on it and is of interest only as it serves to illustrate a few methods in building odd structures.

In building these blades the holes were punched in the bars but left out of the angles. It is difficult to locate holes in several pieces before bending them and have the holes match after they are bent. After the angles were rolled the plates were clamped to them and the holes burned through the angle and reamed, the whole structure is assembled to a dummy support which corresponds to the support it will have in use.

The blades are then assembled at the right height from the floor and the splice bars tacked on. After the piece is knocked down the welding is completed.

This set of blades is thirty feet in diameter. A sixty-five foot blade has eight supporting trusses and becomes quite a welding job.

The floor shown in this picture is one of three in the welding shop. They are built of ship channels tacked to beams and are leveled within a fraction of an inch. There is also the advantage that material may be bolted down to them to hold it straight or in place while welding.

BULKHEADS

Figure 10 shows the doors for a pair of bulkheads for the construction air locks of the Chicago subway. By tacking these up complete before starting welding and by back stepping the welds we were able to hold these plates flat except for a few inches at the corners. The corners were straightened cold. The one in the lower right corner already has the rubber seal assembled on it. The round holes are for five-eighths plate glass windows.

All our work is fitted up and tacked before the welders start on it. The fit-up men can all tack and they can also do any minor burning required to obtain proper fit. If there is any considerable amount of material to be cut a template is made and it is cut ahead of time. In the case of one piece here or there the fit-up man takes care of the burning.

The fit-up man also marks on the piece the size and location of the welds. The piece is then turned over to the welders. The welders move from place to place with their machines as much of the work is too bulky to take to them or the movement of it would upset the alignment. We find that one welder on the general run of material can take care of from two to three fit-up men.

On small jobs requiring a plate to be rolled or a few holes drilled and tapped and the structure fitted up, the preparation up to the point of welding is all turned over to the fit-up man.

This is especially true of pipe railing. The fit-up man makes his layout measures and cuts his pipe and then tacks the railing together.

MAINTENANCE OF WAY WELDING*

By C. E. MORGAN†

RAIL JOINTS, FROGS, CROSSINGS AND BUTT WELDING OF RAILS

Rail End Welding

THE largest field for welding has been the building up of the battered material at the ends of rail over the rail joint bars. This work started about the time of the World War and has progressed quite steadily since that time. The depression years gave a great impetus to the work after it really got into its own about 1930. Most of the early work was done with the oxy-acetylene torch while in recent years we find quite a few railroads also using the electric arc.

There were a lot of different opinions floating around as to the hardness desired, so there also were various welding rods supplied for the same purpose. More data are being assembled constantly and many tests have been run to show that hardness values of less than 320 Brinell are not effective in preventing rail batter and that welded rail of 450 Brinell still is much higher in ductility than any rail in its "as-rolled" condition. Therefore, one should get the hardness he desires to accomplish the result he wants for a specific territory. In other words, to build up a rail end we can just as well replace material that was 220 Brinell with material added that will be 350 Brinell or even 400 and get the added wear and longer life from it.

It might be well to mention at this time that Brinell hardness is not an absolute measuring stick for making comparisons of resistance to batter. Grain structures and methods of welding may affect results that are somewhat hard to correlate.

1. *Gas Welding.*—Gas welding of rail ends is usually done by working a gang of from 2 to 20 welders, who use long lengths of hose so they can reach several joints from the tanks. It is customary to manifold the acetylene cylinders and to use a single oxygen cylinder. The joints are built up and usually surface-ground by a machine designed for that purpose. Some roads prefer to use small gangs and finish by the hammer and flatter, while the general trend is to finish-grind the welded joints. After the surface grinding, the cross grinding or slotting is done to provide an opening for any flow which occurs to prevent chipping.

2. *Arc Welding.*—Arc welding of rail ends is usually preceded by a preheating to about 500° F. One-quarter-inch electrodes are most common while $^5/_{16}$ are also used for this work. It is regrettable that a good welding rod for this work is not yet available. It should be about 24–30 inches long with a light coating and the bare spot for the electrode holder should be in the center so the welder could work up to the holder, flip it over and work up to the holder from the other end. All stubs thrown away represent a loss and the operator's time is also wasted. This would always keep the holder no farther away from the arc than 12 to 15 inches while they are now 18 inches from it on that length electrodes when they start each rod. Since none of the rail rods fall in the shop group as to analysis, why do they follow it for shape?

Arc crews may have from one to as many as four arc machines, either on or off track depending on traffic conditions. Surface grinding and cross grinding are always employed for finishing up the work.

Frog and Crossing Work

1. *Manganese.*—Manganese frogs and crossings are being reclaimed both in the field while in track and also

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.

† Superintendent of Work Equipment and Welding, Chicago, Milwaukee, St. Paul and Pacific Railroad Co., Chicago.

by being shipped to the central repair yards or maintenance shops. The electric arc is used exclusively for building up the worn parts and they are finished by grinding. Our friends in the metallurgical work advise us that it will always be impossible to properly weld manganese steel on account of the way it is made and quenched in water, but they also say that if we weld it, to be very careful about not getting the casting too hot, lay long narrow beads and be sure to peen the welds. Many people are successfully welding manganese and better results are being obtained each year. Many early discouragements were caused by amateur welders armed with poor electrodes working on a portion of a casting where sand and stress were the opponents. Better foundry work and improved designs have eliminated many such cases.

2. *Open-Hearth Steel.*—The turnout frogs, spring frogs and rail type crossings are welded by either the gas process or the electric arc. I believe I am safe in saying that well over half of this work employs the gas process which has been employed on rail steel for a longer period of time. The trend toward using the electric arc has been led by those roads where shipments of gas were long and the return of the empty tanks a problem. The arc crew uses more welding rod and grinding wheels than the gas crew, but each welder makes a faster deposit.

The gas welding of frogs and crossings requires about the same equipment and materials as the gas welding of rail ends. Some roads desire a harder deposit than others and may quench the weld with water even after having used the same welding rod. It might be significant to mention here that in a terminal like Chicago one road with about 1600 turnouts finds their annual replacement of frogs less than 160 per year. Before field welding started this was averaging about 400 frogs per year. Most railroads agree that a frog can be welded in place for what it would cost to unload, change out and reload another frog. The stock of frogs carried to protect the road would need to be larger if it were not for the field welding of the ones in track.

Butt Welding of Rails for Long Lengths

There have been employed several methods of joining two rails to eliminate a rail joint. It is quite believable that the first butt weld was made at some roadmaster's request to bridge some very poor ties which were in the middle of a wide highway or street. Gas welds were made and joint bars put back on that were already worn out and, after lasting a few years, the rail weld would break. The idea of eliminating the joint was firmly implanted in the minds of a few men who did some early experimenting, and it has grown to where one railroad has well over thirty miles of continuously welded track located over its lines.

The rails are joined by a free held gas torch, electric resistance weld, thermit welding, or by a gas heating and pressure combination. Some of these hold very good promise for a high quality weld that will last a long time. The type of plate and hold-down device to keep rail in place seems to be the item which so affects the total cost of the welded track. Tests are in progress now and data are being assembled that will determine the future extent of its use.

BRIDGE WELDING

New Structure

Bridges are being designed with quite a little welding in the fabrication of members. The rolling of larger beam sections has been a help to the designer who wishes to use a welded design. Some bridges have been put in recently where each panel or section was a completely welded unit. Five such units made up a bridge for four tracks to run over.

There has been a weight saving of from 12 to 15 per cent in some designs while as high as 17% has been recorded in special cases. It is quite probable that more welded designs will appear as maintenance charges are made available on the ones which are in service.

Repairs to Existing Structures

1. These repairs may include a strict replacement of a corroded or worn out member. It may also be a small patch or a part of a member. Circumstances do not permit access to the far side to facilitate backing out rivets or reriveting. Welding can be employed for work in this class after cutting out the portion to be removed. This has been done by many roads.

2. *Increasing Capacity.*—Many bridges were built when railroads thought 40 cars a big train. They now find much heavier loads on them with 80 car trains to meet competition and requiring larger engines to pull them. I have been told that there are quite a few bridges today that have been strengthened by welding to now carry a much larger load than they were built for 30 years ago and now have a larger factor of safety.

BUILDINGS—WELDED STEEL

New plans for buildings of almost every description call for a certain skeleton of steel about which a wall and roof are attached. Each year it seems that the builder wants more permanence than the year before. One railroad recently built a large fruit house in which the steel work was 100% welded fabrication. It is being noted that alterations in design may actually be made after construction has started and some steel is erected. Welding brings up a means by which one member can be joined to another without having to drill or punch more holes. The world is gradually and cautiously studying the merits of welding in this field and it is a rapidly growing enterprise.

Alterations

It becomes necessary to build an annex to an existing structure without disturbing the steel frame or marring the inside wall of a building. Bricks may be removed and foot angles or knee braces can be welded to a column and the members attached without the vibration of riveting hammers cracking plaster or scattering dust. An electric arc is not without sound but it is not very objectionable when in the next room.

EQUIPMENT USED IN MAINTENANCE OF WAY

Continuous Use

It is not fair to compare the maintenance of a unit which is out on the right-of-way to one like a locomotive or car which goes to the yard or shop for service every day or every week. That equipment must be made well and it should stand continual usage without repairs. You will notice that such units as motor cars, draglines, shovels, ditchers, ballast machinery, adzers, spike pullers, bolt machines and others have taken advantage of welding in their maintenance.

Design

The economy of the design of welded construction is too self-evident to have any more than a reference here because you know it and I like it. We like to see a lot of parts assembled so they become one part.

AUTOMATIC GAS WELDING

Oil Float Assemblies*

By HARRY E. LERNER†

IT IS not our intention to enter into a technical discussion of automatic gas welding, but rather to treat the subject from the standpoint of our experience and research pertaining to our own product. Therefore, if any of our findings are of interest, we shall be glad indeed, to pass them along. You will, however, appreciate that we are not specialists in this type of work, and that this is all quite new to us and represents our first attempt at gas welding, which was brought on us by necessity rather than desire.

Possibly some enlightenment would be in order at the moment on the product that we are making, its inception and function. With this thought in mind, we will only endeavor to give you some of the highlights of the problems of proper lubrication, going back fifteen or twenty years and bringing it up to the present-day demand to give you a better understanding of the many problems that are daily encountered.

Much has been learned and many improvements have been made on internal combustion engines. From an engineering standpoint, we believe the lubricating system, regardless of its mechanical nature, represents the heart or the one phase that must be handled correctly if the maximum in efficiency, function and life is to be achieved. It would be quite surprising, indeed, to the average layman how little was known of this problem ten or fifteen years ago.

Formerly, an engine producer, designing his engine, and after getting into difficulty, would call on the oil companies to figure out a lubricant that would solve the problem, rather than getting this engineering advice during the designing stage. It was impossible to standardize a lubricant at that time owing to the many designs and systems used.

It has only been in quite recent years that builders of engines have standardized on FULL FORCE-FEED LUBRICATION, which has been generally accepted by the industry as a whole in the United States and on the Continent. There is, however, one of our prominent builders who still uses splash and one prominent builder who is still using the semi-plunger type pump.

During this era we have had many problems. Particularly is this true of the handling of cold and clean oil, as the viscosity in general use, was rated as S. A. E. 30 or S. A. E. 40, with the result that temperatures from thirty above to zero and below made it very difficult to handle the oil, thus causing loss of seal, ice-locking, cavitation and, of course, other problems that we will not attempt to discuss here.

Of the problems mentioned, possibly the most serious factor was that of loss of seal and ice-locking. At this point is where the floating type of intake came into the picture—to cure this evil. This seemingly was quite simple, as in the old types of pans and designs, intakes were placed at the lowest part of the pan or sump with the result that condensation, abrasives and foreign elements would naturally settle to that point. When an attempt was made to start the engine, ice that had formed at point of intake was what we refer to as, ice-locking.

The float has an entirely different principle. It takes its supply from the top of the oil, where the oil is purest and works on the principle of isolation. Therefore, you would not be concerned with that which had settled out, or the condensation. Obviously, if you can isolate the water or ice formation, you have isolated the abrasives and emulsification, which gives you an added advantage; namely, it is not required to circulate any of the destructive elements from the bottom of the pan, under these conditions.

This has been a contribution to longer-life bearings, easier starting and better function. However, this represents a lot of research, for in the control of the buoyancy of the floating member, your position in the oil must be maintained in temperatures from 50° below to 300° F. above on the basis of 10-W and 20-W oil, so that a vehicle can properly function whether being operated in Western Canada or in the desert. Additionally, the unit must be so designed that if your screen becomes plugged your by-pass will function assuring one hundred per cent seal.

THE NECESSITY FOR FLOATS THAT ARE POSITIVE

We hope we have made clear the necessity of a float actually being a float, for if it did not, it would fail to be an improvement. Since the speed of engines and designs calls for numerous pan changes owing to mounting requirements, other problems have entered.

The proper dissipation of heat has been a serious problem. Many improvements have been made in this respect; crank case ventilation and the proper blending of oils to insure functioning. In making these last changes, we are again concerned with a crank case varnishing, which is one of the present-day headaches, and the proper dissipation of heat. Therefore, the Float that was formerly soft-soldered as nearly one hundred per cent perfect as possible is a decided uncertainty in modern engines.

Some of the heats developed at maximum r. p. m.'s, melted solder to a plastic stage. Therefore, it was necessary for us to devise ways and means of building a product that would still function one hundred per cent under these conditions.

After experimenting with the various ways and means of accomplishing this, we found that acetylene welding seemed to offer the safest method. It is not to be understood, however, that we are condemning any other method. Owing to the peculiarities of our product, it would not lend itself to some quite well-known methods.

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.

† Taylor Sales Engineering Co., Elkhart, Ind.

Fig. 1—Float O-Oil Suction Intake Finished

Fig. 2—Float-O Assembly Parts, Cover and Body Prior to Welding

PROBLEMS IN WELDING

The material used in our Float bodies is 28 Gage Terne Plate, in which our tolerance must be held within plus or minus three thousandth inches, of which we try to hold to the plus side. At the best, it is a very light metal to handle in welding and mention should be made that a better selection of metal is required.

Our first attempt was revolving the body with the lower cover assembled, holding a torch with one hand and revolving with the other, which, of course, gave us an idea that this could be done if the proper controls and assembly could be worked out.

After the proper analysis of what took place in the metal, strength, etc., several of these units were completed and given very rigid tests to thoroughly satisfy ourselves that it would do the trick. We then developed a special table with the controls and gages mounted upon which we could control the revolutions from, say, fifteen seconds to one hundred twenty seconds.

On this table experimental work was carried on with preheating torches with a 15-second cycle. We found that the preheating torch did not seem to offer any advantage, but rather was a disadvantage. From this point, we used the single torch starting at forty seconds and working up to one hundred twenty seconds. With all advantages and disadvantages recorded, we found that eighty-second cycles offered the most uniform welding.

Of course, we had the problems of the mounting or control of speed and adjustment of torches, but at this period it was quite evident that all there remained for us to do was to work out the mechanical details. However, in getting control of the speed we had lost sight of a very important factor—and that was the creep of the parts.

Our runs were not of long enough duration to offer some of the disadvantages that were later found; namely, we were using a weight to hold the parts together, and found, when adding the weights, that we had a very decided change in the heat characteristic. We were developing back pressures which made the holding of the two parts, or the elimination of the creep a very serious problem. To be quite frank, it appeared that we were hopelessly sunk at this point. Since a very definite relationship had to be held between the two parts, it was a problem of getting an interlocking action sufficient to hold.

This problem was overcome by the building of new dies to control the flange portions, assembling, in press to get the interlocking action, and by adding a further operation in the press to push the flanged portions inwardly to an angle of approximately 30°. This, of course, required experimental work up and down the range until we had finally located the correct angles for holding.

We are happy to say that this has worked out very successfully, and we are able to do a very consistent welding job. With the elimination of back pressures, we likewise reduced the rejects from as high as 30% to approximately 4%. This 4% is not a problem since each piece is individually inspected, as it is quite simple to repair the pinholes by flashing with the torch.

COSTS, EQUIPMENT AND PRODUCTION

In addition to the various problems previously explained, this improvement had to be accomplished without penalizing the cost to our users.

This phase of our development was quite interesting. Our first attempt for a production machine consisted of six turntables on a basis of 115 seconds, which required two operators. From this machine, we worked out various improvements, ways and means to establish definitely an eight-station unit which is now in operation,

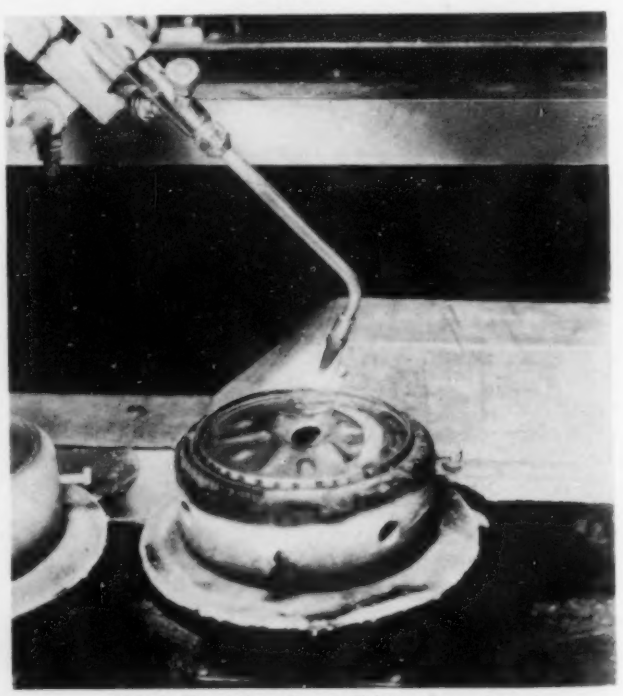


Fig. 3—Close-Up of Torch Welding Operation

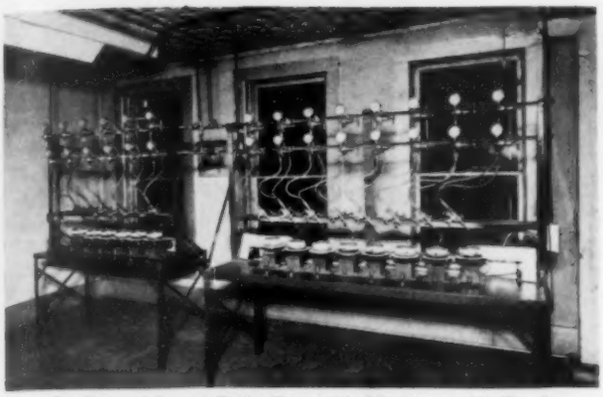


Fig. 4—Six Turntable and Eight Turntable Machines with Torches and Regulators

and which is being at present handled by one operator on a basis of eighty seconds.

This will, so far as we know, at present be our standardized unit, and more of these are now being gotten into readiness for peak production. The basic eight-hour schedule for each machine with one operator is approximately 1500 finished units per eight hours.

The cost of the table, fixtures, etc., runs approximately $750.00 for the eight-station layout. Our costs have been decreased very materially with this change. Our percentage of rejects are running lower. When we refer to rejects, we mean the hospital line. We are at present producing these finished units, so far as the welding is concerned at 72¢ per one hundred pieces.

If you have not already viewed this machine in operation, it is possible to do so at the show where one of our experienced operators is giving occasional demonstrations.

At this point, we wish to express our most sincere thanks to the Air Reduction Sales Company, who very graciously assisted us both with their service engineers and their engineering staff to make this possible. We are, additionally, very grateful to the Boston Gear Works for their contribution on turntables.

The success of our operation is definitely assured. As a matter of fact, our entire production for 1940 will be handled in this manner. We do, of course, have other operations, such as a heavy duty Float that is used in certain types of engines and on some of the pleasure car engines that have oil capacities up to fifteen and eighteen gallons, which we are silver-soldering the tube to cover, the tube to body and the stop to tube.

SHRINKING OF STEEL

To Correct Distortion from Welding and Forging*

By SAMUEL T. SMETTERS†

WHEN steel is welded or forged, local contraction takes place at point of welding or forging, which may remain as locked-up stresses or appear as distortion.

The amount of shrinkage depends on amount of heat, rapidity of heating, linear coefficient of expansion and contraction, coefficient of specific heat, thermal conductivity, also the rate of cooling. Some of these factors may vary with different grades and alloys of steel.

If the heat is dispersed gradually throughout the entire section, distortion will be avoided and shrinkage will be uniform.

There does not seem to be any exact knowledge regarding shrinkage since the rate of expansion increases with temperature. The rate of contraction must be at much higher rate at the higher temperatures and must be at a lower rate when approaching the temperature of air.

This may be in appearance only, as it may be the rate of cooling is so much slower so that the final shrinkage at the finish may be at the same rate.

We note in welding the shrinkage is lessened if the weld is protected, allowing the heat to dissipate throughout the entire mass. So protect welding against drafts and sudden cooling.

So in heating for shrinkage one should heat quickly the section one wishes affected and cool quickly by water or compressed air.

Quite often the effect that heat produces does not seem reasonable, but when one considers that there might be locked-up stresses being relieved and that after that happens it may not shrink as expected, it is easy to understand.

Sometimes it is well to correct minor distortions immediately by heating and shrinking, counteracting the effect of welding.

A beam or plate may be rolled when one portion of section is hotter than another or slightly a different composition, with the result that when cold it will have locked-up stresses.

A beam may be straightened cold and some of these stresses do not produce a set, others do, and the beam is straight. But certain stresses are locked-up.

A plate may be straightened by a series of stretching; this produces certain stresses which become locked-up.

Any steel section having locked-up stresses when heated will react to relieve them as well as shrink.

HEAD GATES, LOCKPORT POWER HOUSE

Gate composed of beams, horizontal across, with beams and channels on either side with diaphragms, rollers, equally spaced, projecting 1 inch beyond the face

* To be presented at Annual Meeting, AMERICAN WELDING SOCIETY, Chicago, Oct. 23 to 27, 1939.

† Civil Engineer, The Sanitary District of Chicago.

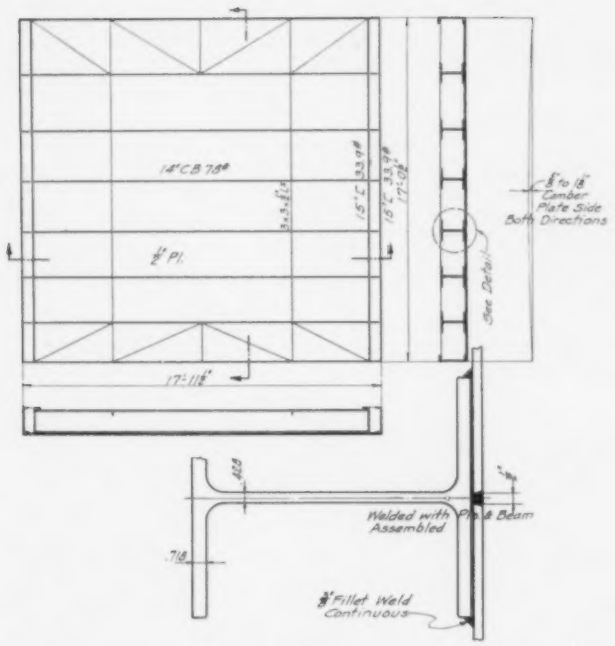


Fig. 1—Head Gates

of gate. The skin plate is $^1/_2$ inch thick. The welding specified, $^3/_8$-inch fillet-weld continuous and around the periphery of all steel in contact. The $^1/_2$-inch skin plates were separated by $^1/_2$ inch and spliced at beams with penetration weld in beam. So at each splice plate beam there are two $^3/_8$-inch fillet-welds continuous and $^1/_2$ inch x $^1/_2$ inch butt weld of plates with full penetration weld to beam (Fig. 1).

Beams, channels and plates were correctly assembled and tack welded, then completely welded as specified.

When cool, the gate was badly dished concave on plate side.

There was an excess of welding.

The gate was blocked up and heavily loaded with steel beams causing it to dish $^7/_8$ inch beyond the true plane (some heat was applied). When the load was removed it showed little or no set.

I then suggested the following procedure of heating and shrinking.

The flange and part of the web of each beam was heated in sections of two feet at each heat, commencing at the end of beams. Each spot was heated to 500° to 600° C. and then cooled by applying water with rags. The spots were chosen so that the man heating and the man cooling were not in each other's way.

It required a little better than two days for two men and about one hundred gallons kerosene to accomplish a perfect job.

CHICAGO, RIVER CONTROL, CORNER ANVIL BEAM

The beams were cut to length (14 inches x $14^1/_2$ inches B, 87 lb., 31 feet $3^1/_4$ inches) and flange was formed to 1 foot 6 inch radius around a forming block, the flange first being heated. When forming operations were completed and cooled, the beams had a curvature of 9 inches

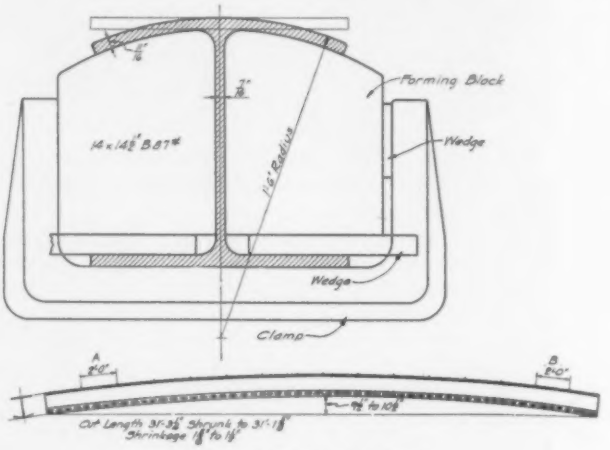


Fig. 2—Corner Anvil Beam

to $10^1/_2$ inches mid-cord offset (Fig. 2).

Each beam was placed, concave side down, on top of a girder beam with side rods to hold it in place. The top flange was heated with gas torch to 500° to 600° C. temperature, working from each end about two feet at a time. Care had to be taken to keep the beam from warping from unequal contraction.

It required three or four tanks of gas per beam.

When straightened, the beams were from $1^1/_2$ inches to $1^5/_8$ inches shorter than original length.

MACHINE GIRDERS

A pair of girder beams with part of one flange burnt-off with attached shelf angle, set back, with fillet-welds continuous, when completed it was $^3/_4$ inch bowed and warped 1 inch (Fig. 3).

These beams we shipped to field to be erected and straightened in field; when it was found that there was no way to brace them to straighten them, it was decided to straighten by heating and shrinking. An open fire

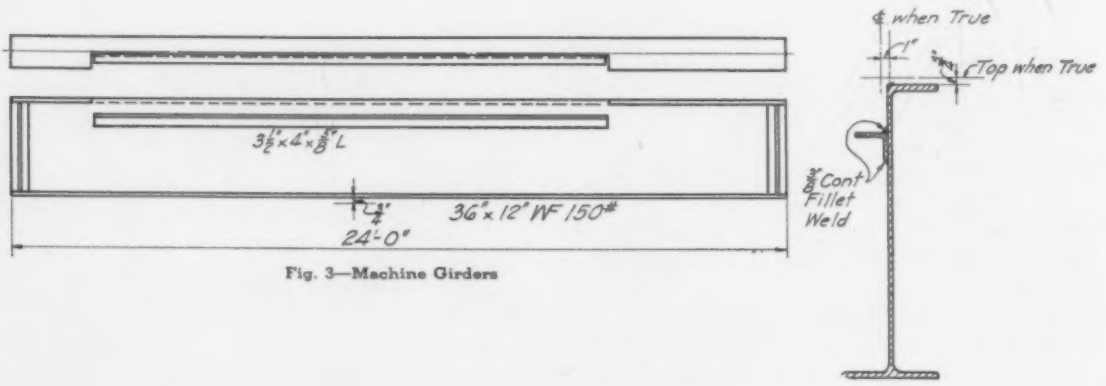


Fig. 3—Machine Girders

was built with wood and coke, flanges heated and cooled, and after several trials were straightened perfectly.

RACINE AVENUE PUMPING STATION

Pump discharge pipe and flange.

Pipe made of $^3/_4$-inch plate with solid forged or rolled steel flange, finished all over with $^3/_4$-inch fillet-weld on inside plate to flange and on outside flange leg to plate. The inside weld is made first then the tube with flange attached is securely bolted to machine base, similar to large planer table. After the weld from *A* to *B* is completed a mechanic with gas torch heats the flange leg outside of the bolt circle to a temperature of 500° to 600° C. While the weld from *B* to *C* is made and so on until the job is complete. By heating the flange leg to 500° to 600° C. and letting it cool, the stresses are released and the flange leg does not become distorted; in fact it remains in true plane with no need for additional machine work (Fig. 4).

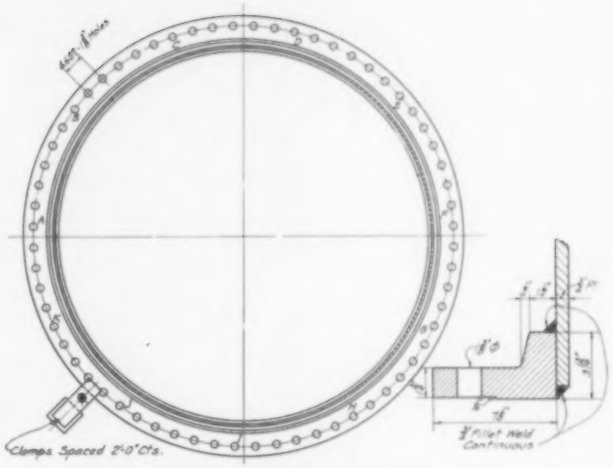


Fig. 4—Pump Discharge Pipe

The time of heating, or time heat is maintained does not seem to make much difference; quick cooling seems to cause the greatest shrinkage. The following questions have arisen and require laboratory experiments and observations to determine the answers:

1. The amount of heat that can be used; whether time kept at same temperature, or repetition have the greater effect or with variations.
2. The amount of contraction possible.
3. Determine the true coefficient of contraction. Also the true coefficient of expansion, of the same steel for comparison.
4. What would be the effect of extreme cold, using liquid air for cooling? These should be determined for the common grades of steel and some alloys, particularly structural steel, medium steel, copper bearing of both, also structural steel with 0.20 nickel and stainless steel.

Figure 5 shows the curve for coefficient of expansion, also dotted, a hypothetical coefficient for contraction based on the following facts: 1st, as a piece of steel is shorter after heating and cooling, therefore the total shrinkage must be greater than the total expansion from the heat. The shrinkage seems to be greatest when it is hottest or in the zone of heat between 600° and 400° C.

The limit of heating is held below 600° C. so as not to change the grain structure of the steel.

I have omitted the discussion of the method of welding to reduce the amount of distortion, contraction or locked-up stresses, and hope at some future time to make a study with this thought in view.

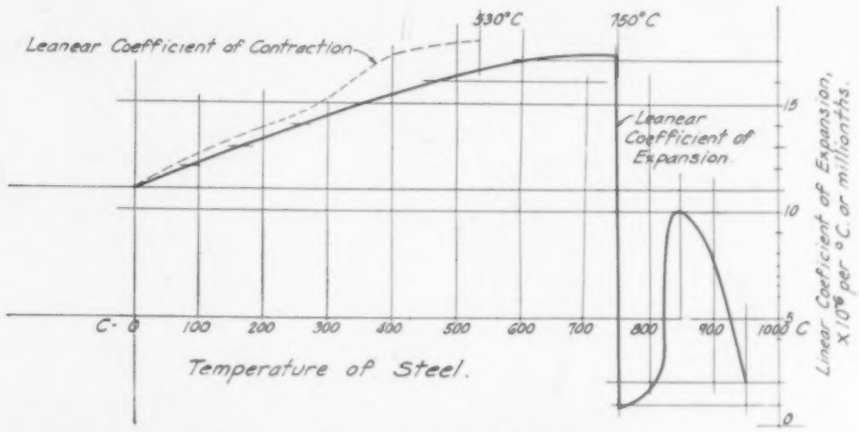


Fig. 5—Coefficient of Expansion and Contraction

PRODUCTION PANEL WELDING OF Passenger and Freight Cars*

By JOHN W. SHEFFER†

PRODUCTION PANEL WELDING, PASSENGER AND FREIGHT CARS

IN 1927 it was my privilege to present at your Annual Meeting in Detroit a short paper on the use of welding in car construction. The vision of the designer then for practically an all-welded railroad car has now become a reality. The vision of the railroads then for a reduction in dead weight hauled by them has become a reality through the use of the newly developed alloys and improved fabrication methods.

In the present paper, I wish to present the more recent developments in the application of spot welding to passenger and freight car construction. The author is not a car designing engineer, simply an equipment engineer in the application and development of welding. He desires to be excused from discussing the technical phases of design.

Today, the railroads are calling for light weight equipment and a large majority of the new cars are using light gage, low alloy, high tensile steel. Conditions surrounding car designs with this new material recommend the fabrication by welding rather than by rivets. The side, ends, doors and the roof of the cars having light gage sheets are spot welded, while the underframe with heavier sections is arc welded.

During the early stages of welding developments, the fabrication was accomplished in very much of a custom-made manner. In other words, each welded article was built from the ground up with few possibilities of utilizing any sub-assembly operations. With the rapid growth of welding in our industry, we must find some more simple means of assembly.

The breakdown of the main assembly operations in numerous sub-assemblies has made for more uniformity and production methods. For example, the side frame structures of passenger cars, although they are not exact duplicates of each other, are enough alike to permit the use of a flexible jig for the construction of all of them. The various parts constituting this sub-assembly are clamped in place and the welding operation begins. The same type of sub-assembly is used in the construction of the roof, end frame and the underframe.

The streamliner has brought new material, new designs, new welding methods which in turn have necessitated the development of new equipment and new technique. The advancement in welding throughout the past few years has been so rapid as to render last year's welding equipment almost obsolete for this year's production. It is, therefore, necessary that any equipment involving an appreciable amount of money must be so designed as to be extremely flexible in its application.

Continual changes in the design of the product also demands a very flexible equipment design. For example, the investment in an automatic welding machine is such that its basic design must be such as to allow for rather drastic changes in the design of the piece to be welded. Even so, the cost of changing over some of the larger machines to meet new production conditions is quite high, yet only a fraction of the original cost of the machine.

New materials, new designs and new welding equipment demand exhaustive experiments, in view of the many factors involved, to establish a proper spot-welding technique. The material and design of any car structure being selected release the plant engineer to select the machine settings which will give the best possible results when all factors are considered.

* To be presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.

† Electrical Engineer, American Car and Foundry Company, New York, N. Y.

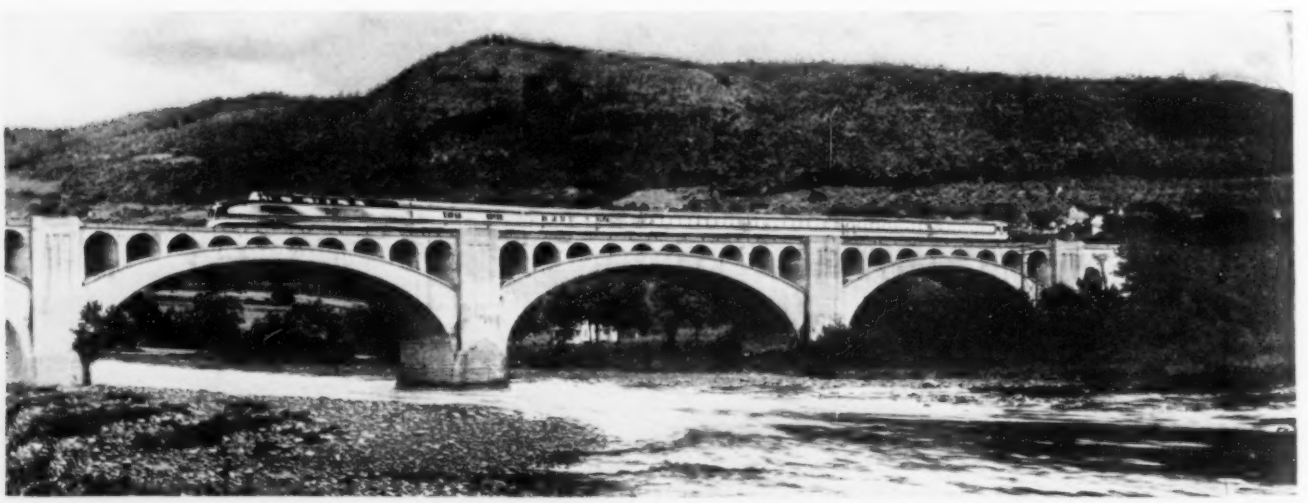


Fig. 1—"Streamliner of Tomorrow," Two Being Built by the American Car and Foundry Today

Fig. 2—Pennsylvania Railroad Diner (103840–78)

PASSENGER CARS

In 1935 and 1937, the American Car and Foundry Company designed and constructed for the Gulf, Mobile & Northern Railroad, three (3) streamlined trains of high tensile, corrosion-resisting alloy steel in which the outside of the cars was perfectly smooth; that is, no rivet heads appeared. The car sides sheathing, as well as the roof sheathing, were attached by spot welding. The roof and sides were built up in reasonably short sections and assembled at the car by riveting the structural members together. A special vertical gap spot welder was located in a pit in the final spot-welding position which attached the side sheathing to the underframe channel above the skirt from end to end. The side sheet and the roof sheet sections were joined by arc welding. The roof sheathing was arc welded to the side sheathing at the eaves to give an unbroken surface between the roof and the side.

During 1939 the Company designed and constructed light-weight diners for the Pennsylvania Railroad, and coaches for the Delaware & Hudson Railroad (Fig. 2).

UNDERFRAMES

Production arc welding, several years ago, found favor in the assembly of the A. A. R. "Z" type center sill in freight-car construction. Today, it is finding favor in passenger underframe design. In fact, due to the wide variations in the thickness of the sections used for the various members in car underframe, arc welding becomes the preferred method of assembly. However, accurate preparation is most important, so that excess weld metal is not required. There is but one seam that may be welded automatically, the others are too short to justify a set-up, hence better hand weld. The various members of the underframe, such as bolsters, cross bearers and cross ties, are first fitted up and arc welded in sub-assembly jigs. The main assembly must have an accurate sturdy jig which firmly holds the various parts to be assembled in their proper places, so they may be properly arc welded into one rigid unit. When production quantities permit, a rotating or positioning jig should be provided.

SIDES

The passenger car sides are of the flat girder type and are assembled in the horizontal position of the welding jig which is the full length of the side. The framing members are assembled on a separate framing jig to which they are firmly clamped into position. Arc welding joins the connections between the framing members. The side sheets of the largest size to be secured from the mill are assembled on the horizontal welding jig and adjusted for frame fitting and camber.

SPECIAL SPOT-WELDING EQUIPMENT

This multiple spot welder is capable of spot welding vertical or horizontal rows of spots on the car side as is required in attaching the post framing flanged U's to the side sheet on the one hand, and the side sill angle and side plate members to the side sheet on the other hand. This spot welding is done individually and consecutively by the direct spotting method. Similarly, the Z-stiffener at the belt rail and the Z-stiffener over the window are also attached to the side sheet by spot welding two welds at each operation by the series method. This welding is done horizontally, panel by panel, through the use of a welding jig car moving on a track underneath the welder platen. The jig car is like a table top covered with a copper grillage that backs up the side sheet to which the framing assembly is spot welded.

A NEW DEVELOPMENT

A new development in multiple spot-welding equipment, through the use of a multiple distributing switch in the secondary or heat-generating circuit, permits the entire group of electrodes to be put under pressure simultaneously. These electrodes act as a self-contained clamp at each and every weld location. They remain in that position through the entire cycle of individual electrode welding sequence. These facilities for applying the correct amount of pressure on all electrodes simultaneously and having them dwell (without time delay) until the various welds are sufficiently cool produce a very clean, strong and uniform weld of quality.

PRINCIPAL FUNCTIONS

The multiple spot welder is made up of the following principal functions:

1. A lift and shift constant pressure hydraulic system, for platen lift and electrode shift.
2. An adjustable pressure hydraulic system, as supply to all electrode cylinders.
3. Multiple mounted transformer units as supply to multiple electrode groups.
4. Primary current supply to each transformer group through ignitron contactor and mechanical timing cams.
5. High-speed secondary distributing switches.
6. A transfer welding jig car covered with a secondary copper grillage.
7. A water-cooling system to transformers, secondary switches, distributing cable and electrodes.

PANEL CYCLE

The execution of a panel cycle is as follows:

The side sheets, together with the side framing unit, are placed on the jig car secondary copper grillage in proper alignment.

The motor-driven jig car through its push button magnetic control is indexed to the panel to be spot welded.

The platen, with a set-up of the required number of electrodes, is lowered to contact the work through a push button magnetic operated control valve from constant pressure hydraulic system. At the same time, the contact shoes of the direct welding transformers make contact with the copper bus bar grillage on each side of the transfer jig car.

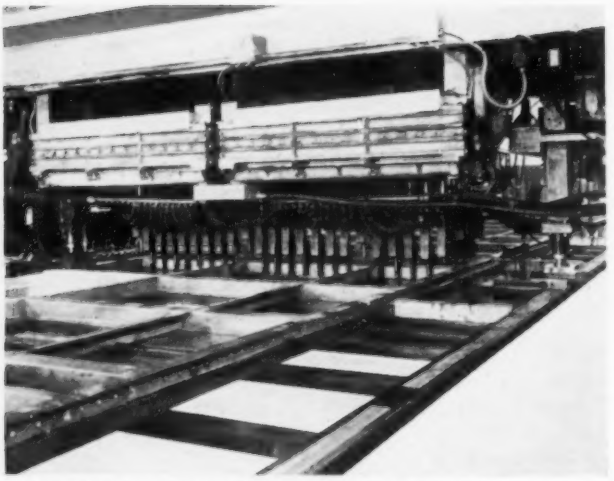


Fig. 3—Welder "Close-Up" Showing Electrodes in Position for Panel Welding of Sides (103855-7)

All the electrode cylinders are put under pressure simultaneously through manual-operated valves and supply from adjustable pressure hydraulic system.

The motor-driven secondary distributing switches pass about twenty thousand amperes to each welding electrode connected to respective segments of these switches.

These switches are started by push button and stopped by a limit switch at the end of their travel and are operated both forward and backward.

Two secondary switches are operated simultaneously on three-phase open delta primary power supply with two welding transformers and two ignitron contactors available to supply current. In this manner, a line of 30 or 40 spot welds may be divided and made in one-half the time.

Two secondary switches are operated consecutively to segregate a group of about 25 spots in sequence of 15 and 10 spots, respectively.

These secondary switches are also operated so as to give two welds at a time as in series spot welding.

Adjustable timing cams operate the micro switch attached to the trolley of secondary distributing switch and determine the desired timing of each spot.

Intermediate spacing of spots requires 1-inch lift of the platen and a 1-inch or 2-inch shift of the electrode mounting and shifting slide. The panel cycle is then repeated as required to meet the spacing required.

When the panel cycle is completed, the platen is raised 4 inches and the jig car is indexed to the next panel.

More than a dozen push buttons, more than a dozen manual valves are assembled on a central operator's control board. Manually, these individual controls initiate any one of a dozen operations. The automatic setting of a selector switch, however, will automatically execute a dozen operations as one.

Duplicate panels may thus be spot welded with dispatch.

Magnetic control through a sequence panel is the brain or nerve center making possible the several functions in the execution of a panel cycle.

FLEXIBILITY OF OPERATION

The push buttons, selector switches, transfer switches, limit switches, contactors and solenoids are interconnected with the entire machine set-up to obtain the following functions:

1. Permit manual control of each welding operation individually if desired.
2. Permit a set-up to be made, which will then proceed automatically to the final pre-set point.
3. Permit any previously pre-set set-up to be interrupted if desired, a single operation performed and then continue the pre-set set-up.
4. Manual termination of any individual operation.

A pipe organist pre-sets his adjustable harmonic drawbars to get his mixtures through a single manual key, likewise the welder operator may pre-set his selector switch and secure a dozen operations through one push button.

A SPOT WELD

In preparing this paper, I have intentionally reduced statistics to a minimum but I should like to leave with you what a single spot weld means in 100-watt lights which you burn in your home as you use one for 60 seconds in a minute, and for 60 minutes in an hour, just 3600 seconds or 100-watt hours.

Such a spot weld requires less than a second and consumes the current of 3600 such 100-watt lights, but the same 100-watt hours you consumed in your hour's reading.

Actual welding time for a car side or a car roof that requires 3600 spot welds is less than 3600 seconds, or one hour. All these spots have tensile values over 3600 lb. each, except in other alloys and thinner gage sheets.

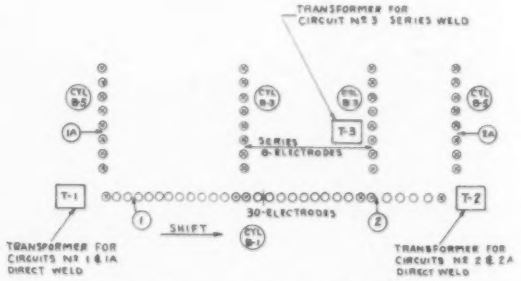


Fig. 4—Diagram of Electrode Locations

THE SET-UP FOR CAR SIDES

The set-up for panel welding of car sides of a given design utilizes three (3) transformers, five (5) secondary switches and sixty-two (62) electrodes, arranged in five groups; two groups of 15 electrodes each take the cross line or vertical post welds; two groups of 8 electrodes each at right angles take the horizontal side sill and side plate welds; a fifth group of 16 electrodes at right angles take the horizontal stiffener welds at the belt rail and the stiffener welds over the window.

These 62 electrodes attached to the spot welder platen through pedestal mountings and shifting slides permit 62 or 124 additional spot welds to be made by a 1-inch lift of the platen and a 1-inch and 2-inch movement of the shifting slides.

It is to be remembered that the copper grillage on the welding jig car backs up the electrode pressure required for welding and distributes the low voltage high amperage current to these electrodes (see Fig. 4).

THE ROOF

The roof framing members are assembled on a separate framing jig to which they are firmly clamped in position. Arc welding joins the connection between these framing members.

The roof sheets are then fitted, clamped and tack welded in position. The roof assembly is now turned over and moved to the spot welder where it is spot welded panel by panel with a two-position set-up of electrodes and a roof jig car covered with a copper grillage to fit the full roof contour.

THE SET-UP FOR CAR ROOFS

In the panel welding of roofs a two-position set-up of electrodes is required to complete a panel.

The first position utilizes four (4) transformers, four (4) secondary switches and sixty-eight (68) electrodes arranged in four groups; two groups of 18 electrodes each take the carline welds; two groups of 16 electrodes each at right angle take the purlin welds. This completes the center rectangle or flat section.

The second position utilizes two (2) transformers, two (2) secondary switches and twenty-four (24) electrodes arranged in four groups; two groups of 4 electrodes each on a quadrant complete the carline welds on the curvature; two groups of 8 electrodes each mounted horizontally take the vertical welds attaching the eave angle to the roof sheets. This two-position operation completes a panel, the platen is raised 4 inches and the jig car is indexed to the next panel to be welded (see Fig. 5).

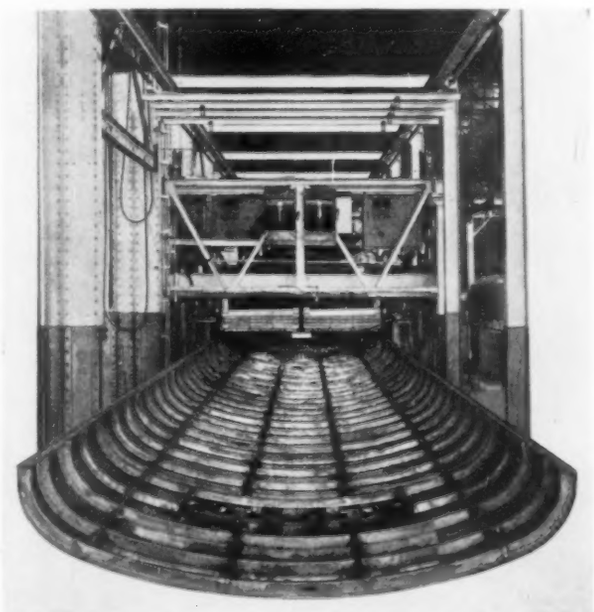


Fig. 5—Welder in Operation with Roof in Jig Car (SP 103832L)

FLEXIBILITY OF APPLICATION

The set-up for panel welding of passenger car sides or the set-up for panel welding of roofs on the same welder indicates the flexibility that may be obtained in the design and application of production spot-welding equipment.

The cross section of the side and the contour of the roof determines the mounting of electrodes on any set-up for panel welding.

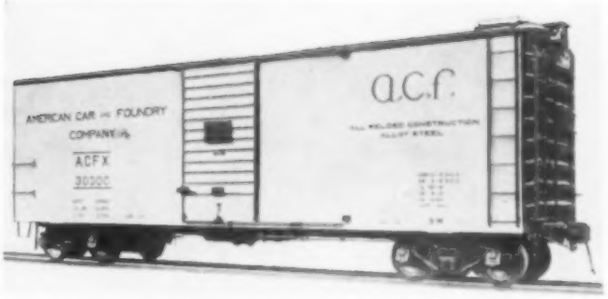


Fig. 6—Welded Alloy Steel Box Car 103801 AA

The same may be said as to the welding jig car secondary copper distribution which back up these welding electrodes.

The car designer's selection of equal post spacing on the car side and his selection of equal carline spacing on the roof determines the number of duplicate panels and the possibility for automatic multiple welding of these panels in any design.

A set-up for panel welding of freight car sides or a set-up for panel welding of freight car roofs is also possible in the application of this welder.

The cross section of the side and the contour of the roof determines the mounting of electrodes in the set-up for any freight car design. The rearrangement also of jig car copper distribution, to line up with these electrodes, becomes necessary.

FREIGHT CARS

The panel welding of a normal day's output of sides and roofs for house cars requires the installation of a special panel welder for sides and a separate one for roofs.

The panel welder for sides has two welding jig cars, which permits a continuous operation of the side panel welder, side after side. The alternate jig car is loaded with side frames and side sheets by the fitters and moves into the welder as soon as the other jig car vacates the welding position.

The panel welder for roofs likewise requires the use of two welding jig cars to permit a continuous operation of the roof panel welder, roof after roof without delay. The one jig car is being loaded with roof framing unit and roof sheets by the fitters, while the other jig car with a fitted and clamped roof moves through the machine welding panel after panel to completion.

Our designers and our shops like the spot welding method of attaching side and roof sheets to framing members on house cars. Slight variations in sheet dimensions are automatically taken care of in lapping of sheets.

In freight cars usually the designer can select equal post spacing for the sides, likewise equal carline spacing for the roofs; the exception being perhaps the end panels in both cases. Duplicate panels resulting permits automatic multiple welding of these panels. This is highly desirable in order to secure maximum production.

The set-up for both the freight car side and roof panel welder depends on the design, but is similar in all respects to the set-up for passenger car sides previously described.

The principal functions outlined in the passenger car welding equipment are required in freight operations.

The execution of a panel welding cycle in freight car welding varies only in detail.

The system of fabrication by welding—of underframes,

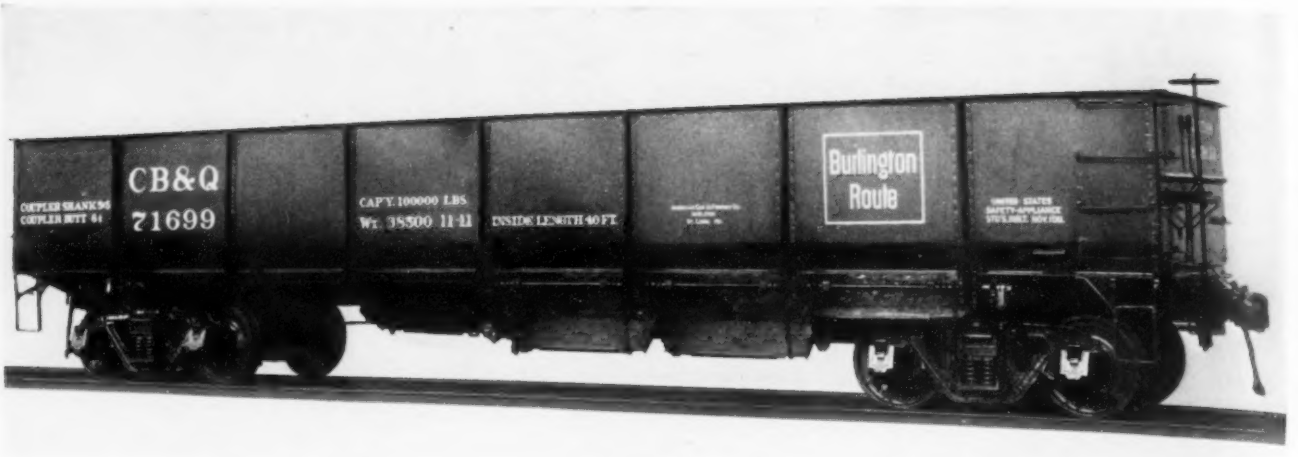


Fig. 7—Chicago, Burlington and Quincy Spot-Welded Gondola No. 71699 Constructed in 1911

sides, roofs and ends of freight cars in jigs apart from the main track assembly—permits positioning for horizontal welding when required and accessibility for more careful work and inspection.

The final assembly by rivets of these main sub-assemblies in track production lines facilitates the desired output and secures economic repairs at some future date.

The American Car Foundry has in service a box of 50-ton capacity and a refrigerator car, both of alloy steel and welded construction.

The light weights of these cars are such that in the case of the box the saving in weight is 4 tons per car; and in the case of the refrigerator car, 5 tons per car. These amounts of weight savings of 8000 lb. and 10,000 lb., respectively, are on basis of comparison A. A. R. riveted steel cars.

The Company's objective in supplying the railroads with cars may be expressed as follows:

1. Equipment of a lighter weight fabricated from alloys recently made commercially available and designs using welding wherever it is economically applicable.

2. Development and installation of new equipment and better technique which will set a higher standard of quality.

3. The "Streamliner of Tomorrow" with smooth side, smooth roof and an attractive contour that will catch the eye of the prospective passenger and create a desire to "ride." One experience by the traveling public in a streamliner with the pleasing interiors and comforts creates the habitual streamliner traveler.

We have been looking forward in welding developments—may we pause for a moment and consider welding developments in retrospect.

For over 25 years, the Company has been a user of 17 stationary spot welders at our several plants to meet certain production demands. We have now over double that number. These welders were manufactured by five (5) different companies. In those days, the thickness of the material to be welded was comparatively light, so that low pressure and small welding currents were sufficient to do a satisfactory job.

Over 25 years ago, to meet special applications, the Company designed and manufactured more than 15 spot welders, several of which were portable. These were the first application and use of portables. There were no such welders on the market.

As far back as 1911, we built the first spot-welded freight car, with welding equipment of our own manufacture. A few rivets were used in this car, but only for the purpose of holding the erected members in place during the spot-welding operation. This method of holding the parts was used instead of jigs on account of the saving in cost, as but one car was built—a "tailor made job." This car was C. B. & Q., No. 71699, and had an official inspection with report in 1925. This report indicated that spot welding stood up to full expectation.

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Welding Society ACTIVITIES—Related Events

A MESSAGE FROM THE PRESIDENT

The 20th Annual Meeting of the AMERICAN WELDING SOCIETY is at hand. It is an occasion for pause and meditation, for taking stock, for appraisal. We, the SOCIETY, now are 3685 strong. Our growth has been in deeds as well as numbers. Though we have done much, we should not be content, for before us lie opportunities for still greater service.

Ten years ago welding involving safety to life and property often met active resistance; today, with few exceptions, it is not only welcomed but invited everywhere that reliability and economy are watchwords. Welded pressure vessels beyond the range of riveted construction are now commonplace; welded ships sail the seas; planes with welded parts soar above the clouds; and welded streamlined trains have won the popularity of the old "iron horse."

H. C. Boardman

To insure safety with economy, these and the many other applications of welding require the guidance and control provided by adequate codes and standards, in the preparation of which the AMERICAN WELDING SOCIETY alone and in cooperation with other organizations has properly taken the lead. The following few codes, among the many, are representative:

1. Standard Qualification Procedure for Processes and Operators.
2. Specifications for Welded Highway and Railway Bridges.
3. Filler Metal Specifications (Jointly with A. S. T. M.)
4. Standard Methods for Mechanical Testing of Welds.
5. Welding Symbols.
6. Welding Definitions.
7. Building Code.
8. Marine Code.
9. A. P. I.-A. W. S. Oil Storage Tank Rules.
10. A. S. M. E. Boiler Code.
11. A. S. A. Pressure Piping Code.

As previously suggested, the accomplishments of the past, however gratifying, should be only the foundation for greater achievements. Existing codes must be kept up to date. New ones must be promulgated. The cost of administration of codes must be reduced without sacrificing safety. Research is needed on many fronts to extend the bounds of our welding knowledge. Constant effort is required to inform engineers generally of new developments and of ways to apply them.

One of the best educational mediums of the AMERICAN WELDING SOCIETY is its Annual Meeting held each year in conjunction with the National Metal Exposition. In one place there is brought together through the presentation and discussion of some sixty papers, through committee meetings and through the metal show, a cross-section of knowledge gained and progress made during the past year. This concentrated education is made available to all who attend. Employers generally find it wise to send one or several of their engineers to these sessions to hear and discuss the papers, attend the committee meetings and visit with their fellows.

Since this is my last official message I hereby thank the entire membership for their help during the past year. As is proper, we have had our differences of opinion, but, in spite of that, have worked together effectively. I am happily looking forward to seeing many of you at the Annual Meeting.

H. C. BOARDMAN

OFFICERS OF THE AMERICAN WELDING SOCIETY FOR COMING YEAR

President—G. T. Horton, President, Chicago Bridge & Iron Works, 1305 W. 105th St., Chicago, Illinois.

First Vice-President—T. C. Smith, General Petroleum Corp., 2525 East 37th St., Los Angeles, Calif.

Second Vice-President—L. S. Moisseiff, Consulting Engineer, 99 Wall St., New York, N. Y.

District Vice-Presidents:

New York-New England: W. F. Hess, Rensselaer Polytechnic Institute, Troy, New York.

Middle Eastern District: L. C. Bibber, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

Middle Western District: K. L. Hansen, Harnischfeger Corp., Milwaukee, Wis.

Southern District: A. J. Moses, Combustion Engineering Co., Chattanooga, Tenn.

Pacific Coast District: L. W. Delhi, Western Pipe and Steel Co., San Francisco, Calif.

Treasurer—C. A. McCune, Magnaflux Corporation, 25 W. 43rd St., New York, N. Y.

Secretary—M. M. Kelly, 33 West 39th St., New York, N. Y.

Term expires 1940:

A. M. Candy, Hollup Corp., 3357 W. 47th Place, Chicago, Illinois.

J. H. Deppeler, Metal & Thermit Corp., 120 Broadway, New York, N. Y.

E. R. Fish, The Hartford Steam Boiler Ins. & Ins. Co., Hartford, Conn.

A. E. Gaynor, J. A. Roebling Sons Co., 107 Liberty St., New York, N. Y.

L. S. Moisseiff, Consulting Engineer, 99 Wall St., New York, N. Y.

*A. E. Gibson, Wellman Engineering Co., 7000 Central Ave., Cleveland, Ohio.

Directors-at-Large

Term expires 1941:

C. A. Adams, E. G. Budd Mfg. Co., 25th & Hunting Park Ave., Philadelphia, Penna.

Marvin Cook, Humble Oil Company, Houston, Texas.

H. M. Priest, U. S. Steel Corp., Railroad Research Bureau, 612 Frick Bldg., Pittsburgh.

C. E. Woodman, Kansas City Bridge Company, Kansas City, Missouri.

*P. G. Lang, Jr., Baltimore & Ohio R. R. Co., Baltimore, Md.

Term expires 1942:

E. V. David, Air Reduction Sales Co., 60 E. 42nd St., New York, N. Y.

J. D. Gordon, Taylor-Winfield Corp., Warren, Ohio.

G. F. Jenks, Ordnance Dept., United States Army, Washington, D. C.

H. S. Smith, Union Carbide Co., 30 E. 42nd St., New York, N. Y.

*H. C. Boardman, Chicago Bridge & Iron Co., 1305 W. 105th St., New York, N. Y.

There is given elsewhere a brief biography of each of the newly elected officers.

*Junior Past-Presidents.

OUR NEW PRESIDENT

Our new President, Mr. George Terry Horton, President of the Chicago Bridge and Iron Company, has built up an organization of men who look out for themselves. Mr. Horton may, in a few words be described as a bold, progressive designer—an engineer with vision and foresight, as contrasted with the engineer who wishes to standardize to make money. One of his outstanding characteristics is his ability to go to the heart of things, brushing aside the non-essentials. Certainly, he possesses to a large degree the capacity to put engineers "on their own"—that is, to give them responsibility and let them find their niche and their own level.

It was during the World War, while Mr. Horton was Assistant General Manager of the Submarine Boat Corporation's shipbuilding plant at Port Newark, New Jersey, in direct charge of all steel that went into ships, that he first became interested in welding; and he has been a strong advocator of welding research ever since, as evidenced by his support of the Univ. of Illinois fatigue tests of welds and the welding laboratory of the Rensselaer Polytechnic Institute.

Here are a few of the high spots of Mr. Horton's career:

Born in Waupun, Wisconsin in, 1873.
Graduated from Rensselaer Polytechnic Institute in 1893 as Civil Engineer.
Married Hazel Heath of Chicago on November 27, 1907.
Started with the Chicago Bridge and Iron Company in 1893 and became President in 1912, which position he still holds.
He is a Life Trustee of R. P. I.
Retired Lieut.-Comdr. of the U. S. Naval Reserve.

Some of his Society affiliations are:
American Society of Civil Engineers
Western Society of Engineers
AMERICAN WELDING SOCIETY
American Society for Testing Materials
Society of Naval Architects and Marine Engineers
Chicago Historical Society
New England Historic Genealogical Society
Chicago Galleries Association

Club affiliations:
Chicago Engineers' Club
The Engineers' Club of New York
Railroad-Machinery Club of New York
University Club of Chicago
South Shore Country Club
Flossmoor Country Club
Aero Club of Illinois

George Terry Horton

He has designed and built many of the largest tanks in the world and some of the most curious in shape; perched on the tops of buildings on stilt-like legs, or at refineries, or beside railroads at watering stations, or on golf courses, or in oil fields, or near gas plants.

Mr. Horton has been on his own ever since graduating from R. P. I. His first job that his father gave him upon graduating was the responsibility of taking a set of surveying instruments and locating the centers of the piers so that the workmen later could drill for the anchor bolts. From the very outset he has had to be on his own.

After this start, Mr. Horton grew gradually into large responsibilities in the firm and when his father died was the logical man to head it. Under him, the character of the business changed. His father had been a bridge-builder; he found himself more interested in tanks, and gradually bridges were dropped in their favor. Hand-in-hand with the building of tanks has gone the building of men.

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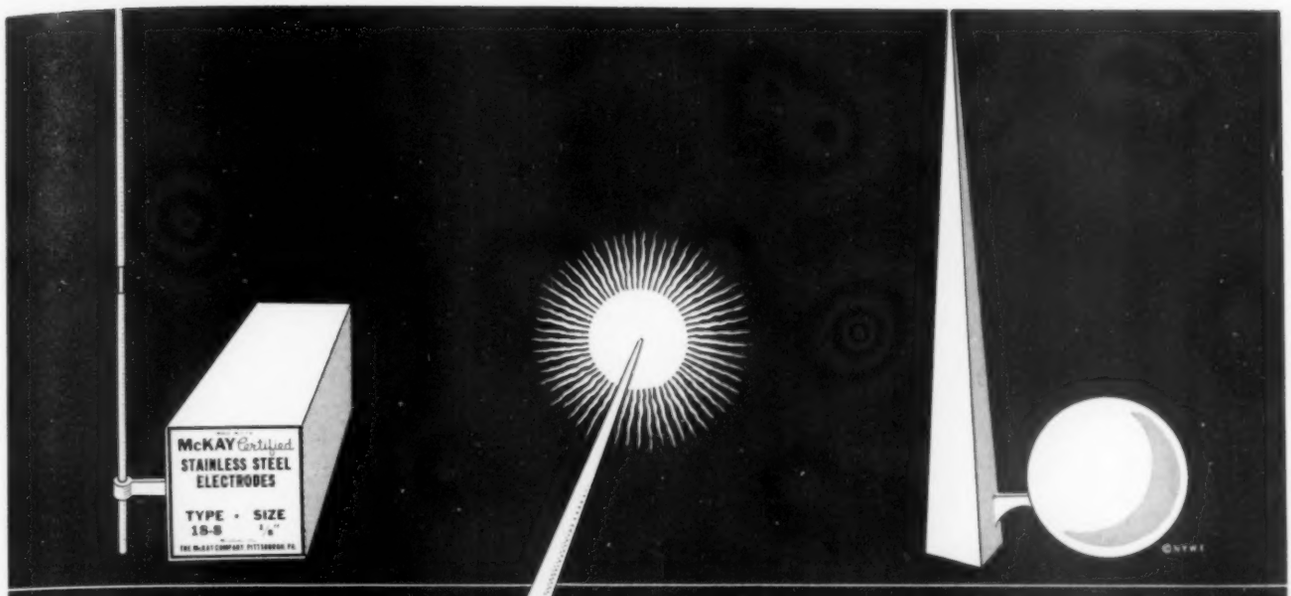

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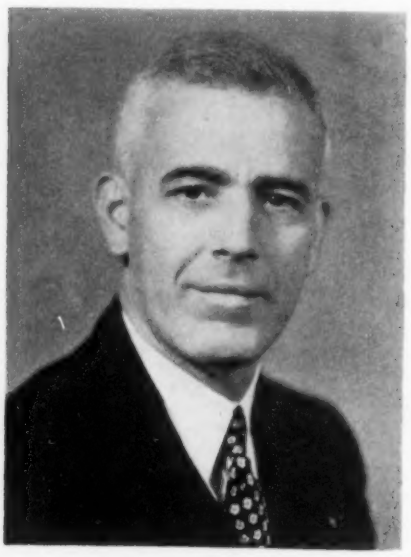
OUR FIRST VICE-PRESIDENT
Turner C. Smith

Turner Church Smith, recently elected First Vice-President of the AMERICAN WELDING SOCIETY, is engineer of inspections for General Petroleum Corporation of California, Pacific Coast Subsidiary of Socony-Vacuum Oil Company. Born in Little Rock, Arkansas, he was educated at the University of Arizona, from which he received the degree of B.S. in Mechanical Engineering in 1916.

He commenced his engineering career as draftsman and plant engineer for International Smelting Co., Miami, Arizona. During the World War he served overseas as an officer of the U. S. Engineering Corps. From 1919 to 1921 he was a designer with A. G. McGregor, Consulting Engineer on copper smelter design; 1922–1923 with H. Kenyon Burch, Consulting Engineer on copper concentrator design, and from 1924 to 1926 with Western Precipitation Co. on electrical precipitators.



Turner C. Smith

Since 1926, he has been with General Petroleum Corporation in the successive capacities of draftsman, chief draftsman, assistant engineer in charge of structural design and engineer of inspections. Mr. Smith is directly responsible for all structural design, foundations, pressure piping standards, oil storage tanks, pressure equipment designs and inspections.

Other engineering activities include the chairmanship of the Engineers Subcommittee of the A. P. I. Committee on Standardization of Oil Storage Tanks, membership in the A. P. I. Unfired Pressure Vessel Committee, and other standardization committees.

Mr. Smith has been a member of the AMERICAN WELDING SOCIETY for eleven years, and has served as Chairman of the Los Angeles Section, Vice-President of the Pacific Coast Region, and National 2nd Vice-President. He is also a member of A. S. M. and is a registered structural engineer in the state of California.

OUR SECOND VICE-PRESIDENT
Leon S. Moisseiff

Mr. Moisseiff is a Consulting Engineer specializing in bridges, structures and materials. He was born in Riga, Latvia, November 10, 1872. He was educated at the Imperial Gymnasium, 1880–1887; Baltic Polytechnic Institute 1888–1890; Columbia University, 1895, C.E.; member Zeta Beta Tau. He was Engineer of Design of the Dept. of Bridges, New York City from 1897–1915; Delaware River Bridge, Philadelphia, 1902–1926; Consulting Engineer, Port of N. Y. Authority, 1927–1931; Consulting Engineer, Detroit River Bridge; Maumee River Bridge, Toledo, Ohio; Golden Gate Bridge, San Francisco, Calif.; Chicago World's Fair, 1933. Designed Manhattan, Detroit, Delaware, George Washington, Bayonne, Maumee, Golden Gate, San Francisco-Oakland Bay, Triboro Bridges, East River Bridges, New York City. Author of "Deflection Theory for Design of Suspension Bridges" now commonly adopted; "Towers, Cables and Stiffening Trusses, Del. River Bridge," Franklin Institute; "Deflection Theory;" "High Structural Steels for Bridges;" "Hudson River Bridge Towers;" "Investigation of Cold Drawn Bridge Wire," A. S. T. M., "Suspension Bridges under Action of Lateral Forces;" "Evolution of High Strength Steels in Struct. Eng.;" "Reinforced Concrete Research," McGraw-Hill, Franklin Institute Gold Medal 1933, American Society Civil Engrs. Norman Gold Medal 1934. Member A. S. C. E., A. S. T. M., Ry. Eng. Assn., A. W. S. Member Joint Committee on Reinforced Concrete, Alloy Steel Committee, A. S. C. E. For a number of years Mr. Moisseiff served as Chairman of the Structural Steel Welding Committee of the American Welding Society.

Leon S. Moisseiff

OUR DISTRICT VICE-PRESIDENTS
Southern District—A. J. Moses

For the past twenty years, Mr. Moses has been connected with the Combustion Engineering Company, or its constituent companies, comprising the Hedges-Walsh-Weidner Division, in Chattanooga, Tenn. He has functioned in the following capacities: boiler shop superintendent, general superintendent, director of research and development work, assistant general manager and general manager of the Hedges-Walsh-Weidner Division. His research

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STATEMENT OF POLICY

The world is entering a crisis, the result of which no one can foresee. Other wars have brought inflation, followed by unemployment and depression after peace was achieved. America's experience in the World War illustrates this fact.

Much of this post-war trouble would have been eliminated by a more foresighted price policy on the part of manufacturers and distributors. Price inflation by the seller when he had a dominant position resulted inevitably in reaction with deflation, depression and suffering. Many of those price increases were not warranted.

Before such an inflationary cycle of prices is again started, we publicly pledge ourselves, as far as possible, to maintain present prices.

Further, if the materials we buy are increased in price, or the cost of labor is increased, then we pledge ourselves to raise selling prices no more than the bare increase in cost of raw materials and labor going into our products.

Further, we pledge ourselves to pass on to our customers the reduction in cost made possible by better manufacturing methods, wider distribution and technical advances in production.

THE LINCOLN ELECTRIC COMPANY

Cleveland, Ohio
October 2, 1939

J. F. Lincoln
President

and development work was mainly in connection with welding. Georgia is his native state. He is a graduate of the Georgia School of Technology, having received the degree of B.S. in M.E. in 1914.

A. J. Moses

Since graduation, all of his time has been spent in the boiler industry, excepting 18 months during the World War, when he held a commission of 1st Lieutenant in the Field Artillery, National Army.

New York and New England District—Wendell F. Hess

Below is given a high-spot review of Dr. Hess.

Degrees: Electrical Engineer, Rensselaer Polytechnic Institute, 1925.
Doctor of Engineering, R.P.I., 1928.

Professional Societies: A. W. S., A. I. E. E., S. P. E. E., Sigma Xi.

Chronological Positions and Titles:

1928 Instructor in Electrical Engineering and Physics, Rensselaer Polytechnic Institute

1930 Assistant Professor of Electrical Engineering and Physics, Rensselaer Polytechnic Institute

1935 Licensed Professional Engineer, State of New York

1937 Assistant Professor, Department of Metallurgical Engineering, in charge of new welding laboratory

1938 Associate Professor and Head of the Welding Laboratory, Rensselaer Polytechnic Institute, Department of Metallurgical Engineering.

Attended some sessions of every annual meeting of the AMERICAN WELDING SOCIETY for the past ten years, in the interest of experimental research and teaching background.

Director, Vice-Chairman and Chairman, Northern New York Section, 1934–1938. District Vice-President, 1938–1939.

Welding Research Committee, and A. W. S. representative on A. I. E. E. Committee on Electric Welding subcommittee on Power Supply for Resistance Welding.

Wendell F. Hess

Pacific Coast District—L. W. Delhi

Mr. Delhi was born in Arizona, November 1892, and is of Danish extraction. He attended Throop Polytechnic and U. S. C. Mr. Delhi was unable to complete his university work and turned to professional baseball for four years before resuming engineering with the Nevada Consolidated Copper Co., at Ray, Arizona, which position be held for four years. He then spent three years in engineering work and contracting in Southern California and about sixteen years ago joined the Western Pipe & Steel Company. He is a member of the Olympic Club, Lakeside Gold & Country Club, Astronomical Society of the Pacific and the Seismological Society. It may be added that for the entire sixteen-year period with the Western Pipe & Steel Company the major problem has been the sales, engineering and mechanical development of welded products.

L. W. Delhi

Middle Eastern District—Leon C. Bibber

Mr. Bibber really needs no introduction to members of the AMERICAN WELDING SOCIETY. He has literally served on dozens of important committees of the SOCIETY and is at present Chairman of the Symbols Committee. Mr. Bibber graduated from the University of Michigan as Bachelor of Marine Engineering. He received his Master's Degree from the same university. Mr. Bibber was formerly Senior Welding Engineer, Bureau of Construction and Repair, U. S. Navy Department, Washington, D. C. At present he is Welding Engineer for the Carnegie-Illinois Steel Corporation, Pittsburgh, Pa.

Middle Western District Vice-President—K. L. Hansen

K. L. Hansen, of the Harnischfeger Corporation, Milwaukee, Wisconsin was born in Norway. He came to the United States in 1901. For $2^1/_2$ years he worked in various shops in Chicago, most of the time for the Western Electric Company, assembling fan motors and arc lamps.

K. L. Hansen

In the fall of 1903 he entered the University of Illinois. From the summer of 1905 until early in 1906 he worked for the Chicago Edison Company in various capacities. In February 1906, he joined the Westinghouse Electric & Mfg. Co. and worked for more than 13 years in several positions. In the fall of 1919 he went to work for the Louis Allis Company (then the Mechanical Appliance Company) of Milwaukee. In this Company he was designing engineer for a. c. and d. c. motors and generators, later becoming Chief Engineer. When he severed connections with this Company he entered upon consulting and development work of his own. The Hansen Arc Welder, first built and marketed by the Northwestern Manufacturing Company of Milwaukee, was invented and designed by him. In the early part of 1932 the Harnischfeger Cor-

Rolled Steel Construction Saves 75% on Fabrication Time, Effects Consequent Reduction in Costs . . .

HERE'S 11,600 pounds of proof that rolled steel construction can be used for faster large-gear fabrication. This gear — with an inside diameter 9'11¼" — was completed in one week. Experience in previous similar jobs showed that it would have required nearly a month to build the same gear with other methods of fabrication.

This gear was made for a user of quarrying equipment. It is built up of six segments. The width of the tooth face is 11¾".

Other widely varied rolled steel applications further prove its versatility, speed of fabrication, economy. In a large rayon plant, for example, all-welded, rolled steel construction made economically possible the fabrication of a continuous spinning machine that sets new standards of precision, produces higher quality yarn. Railroad locomotive cylinders built by welding U·S·S Rolled Steel plates reduced weight 25%—and reduced cost 24%.

Rolled Steel Construction Cuts Time, Lowers Costs in Many Types of Industry

For heavy equipment or light, intricate jobs or comparatively simple ones, this type of fabrication has aided materially in producing better equipment, in less time, at lower cost. A listing of those companies who have used rolled steel construction to save time and money, make their products stronger, longer-lasting and better-looking, reads like a blue book of industry.

The Right Steel in the Right Place

When you fabricate with rolled steel construction, you can put steels with special properties to work in strategic spots. Combine them with one another, with castings or plain steels as the need dictates, to combat destructive forces, reduce weight and give equipment longer life. We offer designers and fabricators, foundries and welderies, steels in widest variety for rolled steel construction. Among them, the special steels, U·S·S Cor-Ten, U·S·S Abrasion Resisting Steels U·S·S Carilloy Alloy Steels, U·S·S Heat Resisting Steels and U·S·S Stainless Steels. And at your command is our wide experience in putting these steels to work where they will best perform.

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

poration of Milwaukee took over the Northwestern Mfg. Company and has since manufactured and marketed the Hansen Arc Welder. He has since that time been acting in a consulting capacity for that Corporation on problems pertaining to welding and welding equipment.

He has written many papers and articles on theory and design of electrical machinery and some on arc welding generators. He has served in the following capacities: Chairman of Committee on Electric Welding of A. I. E. E., Chairman of the Milwaukee Section of A. I. E. E., Chairman of the Milwaukee Section of the AMERICAN WELDING SOCIETY, and vice-president representing the Middle Western district.

OUR DIRECTORS-AT-LARGE

E. V. David

Mr. E. V. David was born in the United States but studied mechanical engineering at the Winterthur Institute of Technology, Winterthur, Switzerland, where he graduated in 1912. Returning to the United States, he was employed by Newport News Shipbuilding and Drydock Company, Newport News, Va. until 1915. He then spent two years as Inspector for U. S. Navy at Bethlehem Steel Corp., Ship Division, Quincy, Mass. Entering the U. S. Navy in 1917 as Ensign, he served on the U. S. Flagship "Pennsylvania" throughout the World War, attaining the rank of Senior Lieutenant. He resigned in 1919 and accepted a position as marine engine designer at Federal Shipbuilding Co., Kearny, N. J. He left in 1920 to go with International General Electric Co. in Buenos Aires, Argentina. Returning to the United States in 1922, he served as an Inspector for Hartford Steam Boiler Inspection and Insurance Company, New Orleans Office until 1924. He resigned to take a position with U. S. Shipping Board, New York, as Inspector, which he held until 1927. He then became connected with N. Y. Steam Corp. as Assistant to the Chief Engineer. In 1929 he went with Air Reduction Sales Company, with which concern he now holds the position of Assistant Manager, Applied Engineering Department. He is a member of A. W. S., I. A. A. and A. S. M. E.

E. V. David

Mr. David has been active on numerous committees of the AMERICAN WELDING SOCIETY. His particular rôle, however has been in the development of the Annual Meeting Programs in his capacity as Chairman of the National Program Committee.

Col. G. F. Jenks

Colonel Glenn F. Jenks, Chief of Technical Staff, Ordnance Department, U. S. Army, Washington, D. C., elected director of the AMERICAN WELDING SOCIETY.

Col. G. F. Jenks

Colonel Jenks was born at Deansboro, N. Y., June 13, 1880. Graduate of Hamilton College (Clinton, N. Y.) B.S. 1901, M.S. 1904. Graduate of Army War College (1924) and of Harvard Business School (M.B.A. 1930). Entered the Army as a 2nd Lieutenant, Artillery Corps, 1901, and detailed in the Ordnance Department, 1903. During the World War served as Colonel, National Army, at Headquarers A. E. F., and at Headquarters Service of Supplies A. E. F. in charge of technical work in heavy artillery in the Office of the Chief Ordnance Officer, and for two months prior to the Armistice as Chief Ordnance Inspector of Artillery at Headquarters First Army. Was decorated by the French Government as Officer of the Legion of Honor and was awarded the Distinguished Service Medal by the American Government.

Since the war served in the Office of the Chief of Ordnance in charge of engineering and production of artillery material, and later in the 8th Corps Area as Chief Ordnance Officer. Was at Watertown Arsenal as Director of Research for two years and then in command from 1932 until 1937, when assigned as Chief of the Technical Staff in the Office of the Chief of Ordnance, U. S. Army. Promoted to the grade of Colonel, Ordnance Department, November 1, 1933.

Member of the A. W. S., A. S. M. E., A. I. M. E., A. S. M., A. S. T. M. and S. A. E. Member of the Engineering Foundation Welding Research Committee and Chairman of the Industrial Research Division of that Committee.

Colonel Jenks has served the Society during the past year as Chairman of the Committee on Outline of Work.

John D. Gordon

Mr. Gordon has been instrumental in bringing about a better understanding between the Resistance Welder Manufacturers Association and the AMERICAN WELDING SOCIETY. Mr. Gordon joined the Kelsey Wheel Corporation in 1923. After 18 months he decided to enter the special equipment field in the design and sale of special equipment suited to the automotive industry. In 1936 he joined The Taylor Winfield Corporation as Manager of their new fabricating plant in Detroit. On Dec. 1, 1937 he was appointed General Manager of their Warren and Detroit plants which position he still holds. Mr. Gordon is an ardent enthusiast of Resistance Welding and believes in the promotion of cooperative research and the intelligent application of sound engineering fundamentals to the design of resistance welding equipment. He is 37 years of age and has one daughter.

John D. Gordon

H. S. Smith

Born in Newark, England, and educated as an electrical engineer at the Nottingham University, Mr. H. S. Smith, after leaving college worked with the firm of Messrs. Robey & Company and then for a time with the Brush Electrical Engineering Company, Ltd. In 1896 he joined the Acetylene Illuminating Company, Ltd., who were experimenting with the manufacture of calcium carbide at Leeds Forge. He assisted in the preliminary experiments there and in conjunction with Mr. S. G. Worth (the founder of the British Acety-

Low Fuming Welding Rods

ANACONDA 997 (Low Fuming) Welding Rod — high strength, tough weld metal with low fuming characteristics—has been added to the extensive line of Anaconda copper alloy welding rods. It is widely used for the general oxy-acetylene repair-welding of cast and malleable iron, steel and copper . . . It is particularly valuable where repairs must be made quickly and easily on machinery parts, automobile engine blocks and similar equipment. Anaconda 997 Welding Rod is manufactured under United States Patents Re 17,631 and 1,525,058. Available from supply houses handling Tobin Bronze and other Anaconda Welding Rods.

BR256

THE AMERICAN BRASS COMPANY

General Offices: WATERBURY, CONNECTICUT · *Offices and Agencies in Principal Cities*

In Canada ANACONDA AMERICAN BRASS LTD., New Toronto, Ontario

ANACONDA from mine to consumer

Anaconda Welding Rods

H. S. Smith

lene Association) turned out the first calcium carbide made in Great Britain on a commercial scale. This work was done at the Falls of Foyers—Portland.

In 1901 Mr. Smith began experimenting with the use of dissolved acetylene and also with oxyacetylene welding. The use of dissolved acetylene was sanctioned by the British Home Office largely as a result of these experiments. General Manager of the Acetylene Illuminating Company and also of the British Autogenous Welding Company, Ltd., and in 1910 he was elected President of the British Acetylene Association.

In 1911 he came to America and joined The Prest-O-Lite Company, Inc., at Indianapolis, becoming Works Manager in charge of all gas plants and in 1918 became Consulting Engineer for Union Carbide Company.

In his long and active career with Union Carbide Company and its associated companies, he has made many important contributions to the oxyacetylene industry, and has been the author of innumerable technical articles on the uses of oxygen, acetylene, calcium carbide and oxyacetylene apparatus. One of the first instruction manuals in oxyacetylene welding and cutting was written by Mr. Smith, and he has been active in the technical training of many men who are now taking leading parts in the engineering aspects of the industry.

Elected President of the International Acetylene Association in 1920 and President of the Compressed Gas Manufacturers Association in 1928, Mr. Smith also has been for many years a director and a member of the Executive Committee of the AMERICAN WELDING SOCIETY. He is also a member of the American Society of Mechanical Engineers, American Society for Testing Materials, the National Fire Protection Association, The National Safety Council, The American Society of Safety Engineers, and a number of engineering groups. In practically all of these associations Mr. Smith has served in important executive capacities.

Mr. Smith was awarded the Samuel Wylie Miller Memorial Medal for 1936.

INSPECTION TRIP

Welded structural frame of a new Diesel electric locomotive under construction. This is the type of motive power used on many of the high-speed streamliners which are recapturing a profitable volume of passenger traffic for the railroads. Shown inspecting the novel structural design are (left to right): E. A. Balsley, chairman of Chicago Section, AMERICAN WELDING SOCIETY; H. C. Boardman, national president of the same Society; and Chas. Dreutzler, welding foreman in the LaGrange, Ill., plant of Electro-Motive Corp., a subsidiary of General Motors Corp. Welding engineers and production executives of metal fabricating plants from all over the country

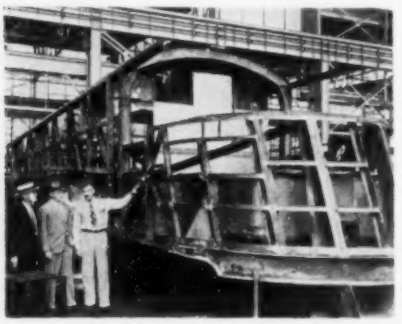


Photo courtesy of Electro-Motive Corp., LaGrange, Ill.

will assemble in Chicago during the week of October 23rd–27th to attend the 20th Annual Meeting of the AMERICAN WELDING SOCIETY.

SYMPOSIUM ON TEMPERATURE, ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY

This symposium will be held in New York City at the Pennsylvania Hotel, November 2 to 4, 1939, by the American Institute of Physics, 175 Fifth Avenue, New York, with the cooperation of the National Bureau of Standards, the National Research Council, and officers and committees of many technical societies.

The program is in charge of representative committees of authorities in various fields, who have arranged for a program of 100 or more papers on scientific and technical subjects, which will be presented in concurrent sessions of selected groups. All interested persons active in science or engineering are cordially invited to attend the sessions, and take part in the discussions of papers. A complete program containing full abstracts of the papers to be presented will be mailed in advance on request to the Institute. It is suggested that those who expect to attend will inform the Institute and make their hotel reservations early. There will be a registration fee of $1.00. The Chairmen of the committees are Gustav Egloff, A. W. Ewell, C. O. Fairchild, J. D. Hardy, H. F. Mullikin, F. H. Norton, R. B. Sosman, C. B. Veal, H. T. Wensel and G. B. Wilkes. H. A. Barton, Director of the Institute, is Chairman of the Main Committee.

GIANT METAL SPHERE

The Carboloy Company of Detroit has installed a 33,760-cubic foot sphere to store hydrogen gas for use in its furnaces in manufacturing tungsten-carbide for cutting tools. The giant metal ball is known as a Hortonsphere and permits a greater cubic content per pound of steel used than any other shape.

The $^5/_8$-inch steel plates used in constructing this metal sphere were dished and cut to size at the plant of the Chicago Bridge & Iron Co. and shipped to Detroit where they were assembled at the Carboloy plant. A patented key system was used in erecting the structure, the key holders being tack-welded to the plates to facilitate accurate adjustment of the plate edges for welding.

Showing the Hortonsphere with Welders on Scaffolding

Photos courtesy of General Electric Company

Showing a Welding Operator Inside the Metal Ball

FIRE FIGHTER HAS 1000-GAL. RESISTAL TANK

This combination pumper and tank was built to specifications of Bert Werder, San Mateo (Calif.) Fire Warden, by P. E.

Courtesy Wilson Welders & Metals Co.

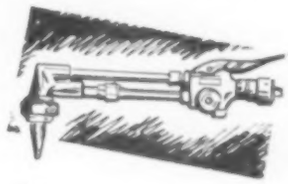
3 times as EFFICIENT as an ordinary torch-

★ NO WELDING JOB TOO LARGE OR TOO SMALL

In welding light sheet metal or heaviest casting, the VICTOR "300" series welding torch is unsurpassed in flame characteristics, gas consumption economy, design refinement and lasting quality.

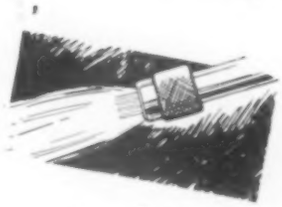
★ 8 DIFFERENT NOZZLE TYPES . . . 69 SIZES

Operator's preference and weld procedures justify a wide range of nozzle types as well as sizes. VICTOR offers 8 nozzle types with a total of 69 sizes.



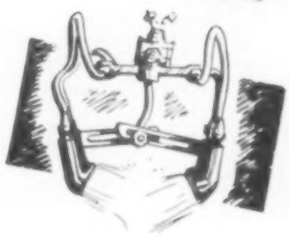
★ INSTANTLY CONVERTIBLE INTO CUTTING TORCH

The VICTOR No. 450 Cutting Attachment instantly converts this welding torch into an efficient cutting torch with a cutting range of up to 10" of metal diameter. Smaller range cutting attachments also fit the "300" series welding torch.



★ MULTIPLE FLAME HEATING NOZZLES . . .

For straightening or bending operations, VICTOR Multiple Flame Heating Nozzles, with large gas capacities, constitute a most useful accessory device fitting the "300" series welding torches. These heating nozzles can also be furnished to utilize, with oxygen, natural gas or the liquefied petroleum gases.



★ FLAME HARDENING NOZZLES . . .

For certain types of flame hardening operations fully water-cooled, multiple ribbon flame nozzles, provided with quenching water facilities, fit these welding torches. Other flame hardening equipments to specifications.

30-PAGE CATALOG minutely describes and illustrates all of the VICTOR welding torch types and sizes and offers comprehensive charts giving gas consumption, pressure adjustment, inner flame cone length and maintenance suggestions.

VICTOR EQUIPMENT COMPANY

WELDING EQUIPMENT DIVISION

844-850 FOLSOM ST. SAN FRANCISCO

3821 SANTA FE AVE. LOS ANGELES

VICTOR DISTRIBUTION POINTS FROM COAST TO COAST GIVE OVERNIGHT SERVICE

Van Pelt, of Oakdale, who manufactures custom built fire-fighting equipment.

The chassis is a White, Model 710. The pump is a 500 gallon per minute Hale-Ford unit, 120-lb. operating pressure. The 1000-gallon capacity tank is of Resistal Stainless Steel.

Tank dimensions are 117 by 79 by 26 inches, 14-gage plate throughout. This was completely welded and is mounted on three 4-inch channels welded to the chassis frame.

WELDED STEEL RIVER TUNNEL

Chicago's new river tunnel, a double tube of steel, 200 feet long, 40 feet wide and 23 feet high, which is to carry State Street subway cars under the Chicago River, will be ready for sinking into position in November. The steel work itself is virtually completed and the work of adding a lining and outer layer of concrete is proceeding.

Most intricate job in Chicago's new subway system, the giant tube will be sunk into position in a trench dredged to a 30-foot depth below the river bottom. The 6500-ton double tube will be sealed at both ends, towed 15 miles to its site and sunk by pouring concrete on its top.

Different from ordinary procedure in tunnel work (which involves boring beneath the river bottom), sinking the section as a unit minimizes the depth of earth covering over it—5 feet as against 15 with conventional practice. The shallower depth has the added advantage of providing a slighter grade in and out of the tube than would be the case otherwise.

Built by Graver Tank and Manufacturing Company of East Chicago, Indiana, the steel tube structure is arc-welded throughout. Every seam is a fusion of steel to steel by the shielded arc process of electric welding.

Structural steel details can be seen in the accompanying illustrations. Refer to Fig. 1 (below) for a general view of the tube under construction in the dry dock by arc welding. In this illustration can be seen the two rectangular positioning bulkheads at either end and the intermediate framing stiffeners. Arc-welding operators, with their strange-looking helmets, can be seen on the structure. Figure 2 (below) shows a close-up of a portion of the tube showing details of the arc-welded construction.

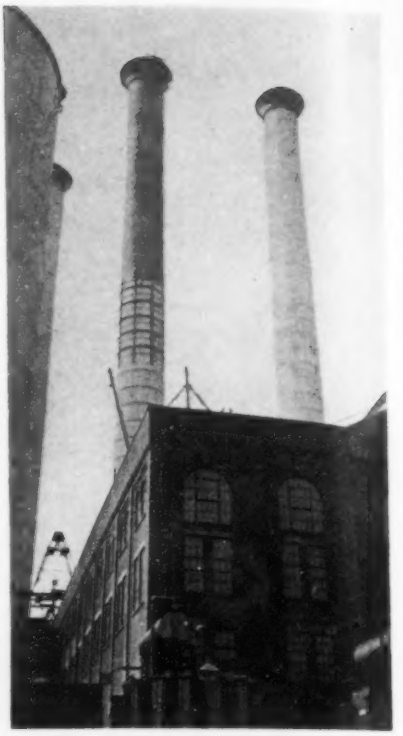
Thickness of steel in the tube wall is $^5/_{16}$ inch. Stiffeners, inside, are T-bars $3^1/_2$ inch x 4 inches x $^3/_8$ inch on 4-foot centers. Holes are punched in the frame and stem of the T-bars on 18-inch centers for the reinforcing rods for the concrete which is to be added. Stiffeners on the outside have $^1/_4$-inch web with angles $2^1/_2$ inch x $^5/_{16}$ inch.

Following the welding, the tube will be given its inner and outer layer of concrete by Merritt-Chapman & Scott, who have the general contract. The plan is to pour part of the concrete in the dry dock. The concrete inside wall will be 2 feet thick at the side and bottom and an average thickness of 3 feet at the top. The tube will be towed from the dry dock into the lake and up the lake to the lock at the mouth af the Chicago River, through the mouth of the Chicago River to its location at State Street, where it will be sunk to the bottom. Steel cables operated from barges at either end will control the sinking. Following submersion, sand and clay will be filled in to restore the river bottom.

Each of the two ends of the tube will fit into a large cofferdam where connections with additional subway sections will be made in dry ground. Caissons on either side of the tunnel in the cofferdam will serve as supports for piers of the new State Street bridge to be built across the river at the site of the tunnel.

WELDED STACK

The illustration shows a welded repair job on a large smoke stack which was recently completed by Craftsmen Welders Inc. of Brooklyn, N. Y., for a Brooklyn utility company.



Welding Assists in Repair of Stack

The main advantages claimed for welded construction on this type of work are, a more rigid structure which reduces the sway to a minimum, and that the seams will be permanently tight as well as having greater strength.

This stack is 230 feet high, 23 feet in diameter at the base and $12^1/_2$ feet in diameter at the top. Repairs consisted of renewing the top 90 feet of stack including cap with new steel of welded construction; welding for strength all the circumferential seams of remaining portion; also installing and welding to stack two sets of heavy steel angle reinforcements of which only one set is visible in photo.

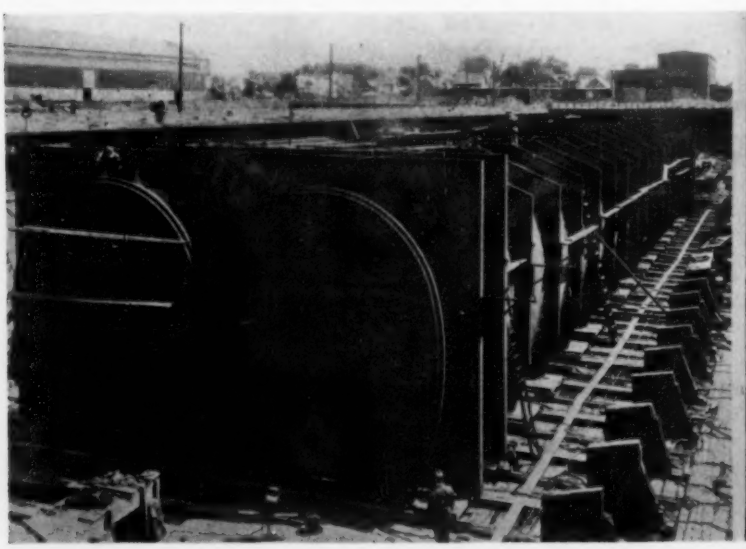


Fig. 1—Chicago's New Double Tube Tunnel Section Under Construction of Arc-Welded Steel, by Graver Tank and Manufacturing Company, Inc., East Chicago, Indiana

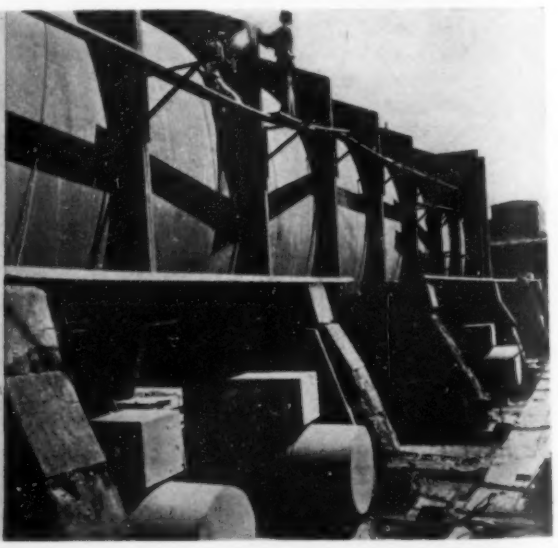


Photo courtesy of The Lincoln Electric Company, Cleveland, Ohio

Fig. 2—Arc Welding the Stiffeners

★ BARE WELDING ELECTRODES

★ COVERED WELDING ELECTRODES

★ GAS WELDING WIRE

ROEBLING WELDING CABLES:

Made in a complete line of rubber and braided types for arc welding purposes.

JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N.J.
Branches in Principal Cities

ONLY A FINE PRODUCT MAY JR **BEAR THE NAME ROEBLING**

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

WELDERS' GLOVES

The Industrial Gloves Co., 928 Garfield Blvd., Danville, Illinois, has recently added a one-piece back welders' glove to its line of industrial safety clothing.

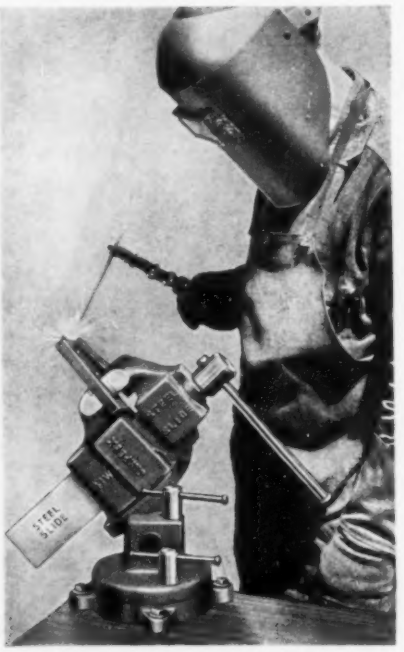
The entire back of the glove is made from one solid piece of leather, thus eliminating burning out of seams, one of the most troublesome features of ordinary welders' gloves. An extra wide leather strap protects and reinforces the thumb seam, and all other seams at points of

greatest wear are welted for extra reinforcement. A wool heat-breaker is securely sewed to the back of the glove, inside, to provide insulation against heat.

WELDER'S VISE

A time and money saver for welding jobs. The double swivel arrangement enables the work to be held in the best position for fast and accurate welding.

This illustration shows this vise in use. Note that the welder does not have to bend or stoop as the work is held in a comfortable working position to insure speed and accuracy.



In a moment's time this vise can be changed into a regular swivel base machinists' vise. The Desmond-Stephan Mfg. Co., Urbana, Ohio.

REMOTE CONTROL

Something new in the field of arc-welding equipment is the recently-announced STERLING G-R Remote Control system. According to engineers of the Sterling Products Company, manufacturers, the remote control system permits current regulation by the operator without breaking the arc and gives the welder constant control of welding heat regardless of the distance between the welding set and actual welding operations.

1. Model 35 with Remote Control Relay and Drive Unit. 2. Remote Control Relay, Motor and Drive Assembly (Interior). 3. Control Switch Mounted on Welding Tongs. 4. Model 35 Transformer Assembly, Showing Manual Current Control

A compact switch mounted on the welding tongs controls a low-voltage relay circuit carried by an auxiliary cable attached to the welding lead. The relays, mounted in a veatilated enclosure on top of the welding set, control a reversible motor which drives the welding machine's current regulating mechanism through a standard gear reduction unit. A control switch has also been provided at the welding set.

Reports on present remote control installations indicate valuable savings in welding time as well as improved quality of the welding. Operator's efficiency is increased (especially on structural or large-scale fabrication jobs where welding is done at considerable distance from the welding sets) because welding current changes may be made without interrupting work. By giving the operator convenient "finger-tip" control of current, quality of the work improves through the use of exactly the correct heat for each type of rod and kind of weld.

THOMSON

HEADQUARTERS FOR
Manual and Automatic SPOT, SEAM, BUTT, FLASH, PROJECTION, PORTABLE GUN, FABRIC and SPECIAL RESISTANCE WELDING PRODUCTION EQUIPMENT
Write for FLASHES, a monthly magazine of Resistance Welding News and information. Sent free on request by
THOMSON-GIBB ELECTRIC WELDING CO.
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SAVE MONEY . . . BY WELDING
Jaw Plates, Gyratory and Roll Crushers, Shovel Teeth, Hammers, Tractor Tread Grousers
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MANGANAL
Reg. U. S. Pat. Office. U. S. Patents 1,876,738—1,947,167—2,021,945
11 to 13½% Manganese Nickel Steel
WELDING ELECTRODES, WEDGE and APPLICATOR BARS, HOT ROLLED PLATES
STULZ-SICKLES CO. *Sole Producers* 134-142 Lafayette St., Newark, N. J.
Sold Thru Distributors Only

GIVE IT THE
"ROUGH RIDING"
TEST*
*TRY A
FLEXARC WELDER
ON YOUR OWN WORK—MAKE ANY COMPARATIVE TEST! YOU'LL FIND WESTINGHOUSE
ONE PRE-SET CONTROL
GIVES ADVANTAGES YOU CANNOT GET WITH ANY OTHER WELDER.

FREEDOM FROM "NUISANCE GADGETS" MAKES FLEXARC WELDER HUSKIER AS WELL AS FASTER

This welding machine will stand rougher handling, harder usage, and higher overloads than any conventional type welder, because it has no fragile meters, fine wires or delicate control parts to get out of order. Note the armored plate frame, the ruggedness of the whole machine. It will take the jars and jolts of moving from one job to another. And when the operator starts to weld — he sets only ONE control and the machine pours in the metal.

See and compare the FLEXARC — prove its ability to take the punishment of heaviest, everyday service — before you put your money into any welder. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7N.

NOW—YOU CAN RENT A FLEXARC WELDER!

Rent a FLEXARC if you like — easy terms, and rental applies against purchase price if you decide to buy any time within one year. Mail the coupon for details.

J-20914

Westinghouse Flexarc Welders

Show Us!

- ☐ Send full details on rental plan.
- ☐ Arrange to demonstrate your machine.

Name_____

Company_____

Address_____

City_____

SIXTEEN AT A TIME

Sixteen sprockets gang-hardened at a time! That's how one manufacturer has solved a knotty production problem of flame-hardening the teeth of rear drive sprockets for one of America's most popular tractors. The trick in doing this work successfully is to make sure that the nested parts are clamped tightly together, since any space between the parts would result in a non-uniform case. In this instance, the 16 sprockets, supported by an arbor, are drawn together by taking up on the nut shown in the illustration. Each

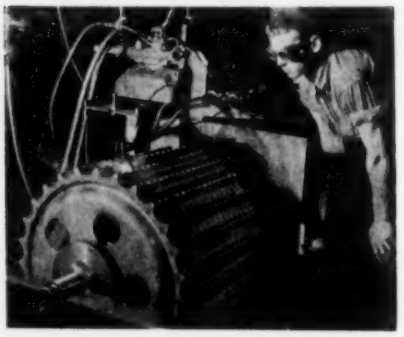


Photo courtesy of The Linde Air Products Company

of the sprockets is $26^1/_8$ inches in diameter, has 27 teeth and is made of S.A.E. 1045 steel. Hardening is performed with two 2 gear-hardening heads attached to blowpipes which are driven by a cutting machine. A speed of 7 inches per min. produces a $^1/_8$-inch to $^3/_{16}$-inch depth of case having a hardness of 70 scleroscope.

THREE FACE SHIELDS IN ONE

In this ingenious model of face shield are three types in one. It has been made practical with a complete interchangeability of parts and the screen, fiber or "plastacele" guard may be quickly buttoned on at the option of the wearer.

When fitted with plastacele window, it is ideal for spot, flash and gun welding, buffing, polishing, wire brushing, die casting, flying scale, etc. . . when fitted with wire screen window, it is recommended for use for babbitting, heat protection, etc. . . Fiber front and glass holder give the wearer complete protection for acetylene welding, burning, scarfing, etc. . . .

Photo courtesy of The Boyer-Campbell Co. Detroit

The windows are buttoned on the spark deflector (fiber forehead guard). Absorbent real leather sweatbands, backed by wool felt, keep perspiration out of the eyes. Plastacele windows are aluminum bound to permit individual fitting to suit the wearer; and with equal protection, with or without correction glasses. When not in use the window can be tilted upward and in that position protects from overhead glare.

PORTABLE PNEUMATIC GRINDER

A new rotary air grinder for small-wheel work, known as the Thor "Bantam" has just been announced by the Independent Pneumatic Tool Company, 600 West Jackson Blvd., Chicago, Illinois. As shown in the illustration, it is but $5^1/_2$ inches long and weighs only 18 ounces. This small size and light weight makes it exceptionally easy to handle for even the most delicate precision work.

Operating at a Free Speed of 14,000 r. p. m. the "Bantam" is suitable for use with a wide variety of accessories. Mounted abrasive wheels in all shapes and sizes from the smallest pointed wheel up to $1^1/_2$ inches diameter round wheels can be used efficiently. Other accessories such as rotary files and steel cutters, sanding disks, wire brushes, saw blades and buffing and polishing wheels can also be used, making the "Bantam" a highly versatile tool for hundreds of jobs.

ELECTRODE FOR FINISH BEADS

A new arc welding electrode, which will facilitate finishing operations on welded products by eliminating the need of dressing or smoothing welded seams in many applications, is announced by The Lincoln Electric Company, world's largest manufacturer of arc welding equipment, Cleveland, Ohio.

The new electrode, known as "Fleetweld 10," is designed particularly for finish bead welding on "U" groove welding in downhand position. The electrode provides full slag coverage and a weld deposit of exceptional smoothness. The bead is uniform and regular without square shoulders. The metal smooths out evenly during welding and the line of fusion with the base metal is practically unnoticeable. Finish beads can be made in V-butt joints in flat position which are flush with the surface of the plates. The surface of the bead made with the electrode has much less of the "rippled" effect which characterizes the usual weld deposit.

"Fleetweld 10" can be used with either normal or reverso polarity with D.C. current, or with A.C. It is made in two sizes in 18-inch lengths, $^1/_4$-inch and $^5/_{32}$-inch, and is packed in 50 pound containers as standard packages.

PROTECT-O-METALS

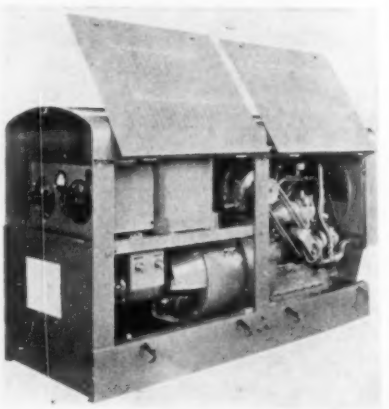
This new compound is claimed to prevent corrosion and the collection of scale and splatter on the surface surrounding the weld. It is stated that it eliminates 80% of the weld cleaning time. Manufactured by George W. Smith & Sons of Dayton, Ohio.

ARC WELDER

A new 300-ampere diesel engine driven arc welder, which is equipped with gasoline engine starting rather than the conventional motor starter with storage batteries, a decisive advance in diesel design, is announced by The Lincoln Electric Company, Cleveland, Ohio.

This new welder simplifies the use of diesel power which was first made available to users of engine-driven arc welders by Lincoln engineers. The diesel engine which drives the welder compares favorably with gasoline engines in dependability of starting, simplicity, weight and cost, as well as in operating speed.

The gasoline engine used for starting the welder is a small auxiliary mounted above the diesel engine. It is started by means of a hand crank. A belt drive, engaged by means of a clutch, connects the starting



engine to the diesel. Starting in extremely cold weather is facilitated by the fact that the cooling system of the small gasoline starting engine is connected into the cooling system of the diesel. This arrangement makes it possible to warm up the diesel by running the starting engine a short time and allowing the heated water to circulate through the diesel engine.

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National distribution service maintains local stocks for immediate delivery—thus minimizing the quantity a user needs to carry on hand to assure adequate supplies. You, too, may find it convenient and profitable to take advantage of this new, reliable source of outstanding electrode values. Call your G-E arc-welding distributor or G-E sales office for further information, a demonstration, samples, or help with your welding problems; or write General Electric, Schenectady, N. Y.

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150-62

CUTTING TORCH

The New Meco Cutmaster Cutting Torch manufactured by Modern Engineering Co. is of 3-tube construction with tubes of Monel metal for maximum heat resistance as well as structural strength. All other parts are of forged and extruded metals.

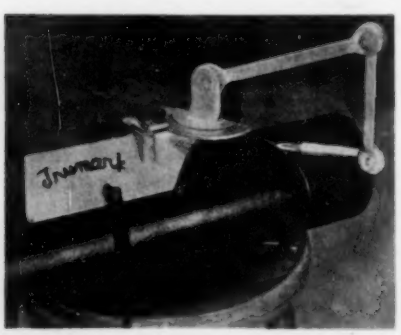
A patented head mixer is claimed to provide a perfect mix of preheating gases and allows for easy cleaning to eliminate overheating. The connection of tip to head is also of patented construction and eliminates leakage dangers both between high-pressure passageways into the preheating passage as well as open leaks that endanger the operator. Much longer tip life is claimed as a result of these two patented features which protect the tip from overheating.

Manufactured by Modern Engineering Company, 3404 Pine Blvd., St. Louis, Mo.

PROTRACTOR

Important savings in shop and field time have been made by the use of the new Trumark Protractor. This marking device gives rapid and accurate cut lines and layouts on any size of pipe, angle iron, I-beams, rectangular shapes and sheets; for torch cutting, sawing or shearing. It was recently introduced by Advance Sales Company, 1003 East Slauson Ave., Los Angeles, California.

This marking device eliminates the use of templates, wrap-arounds and engineering computations, does away with guesswork and saves time and material. It can be used by anyone, in the field or the shop, without previous experience or layout training, to obtain accurate cut marks.



The Trumark Protractor is placed on the pipe or any rectangular shape and is held in level position by a strong spring chain. The level is determined by a bubble indicator.

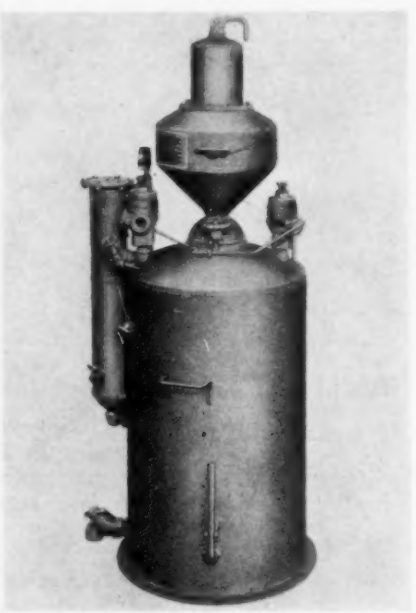
Any desired angle for the cut is set on the 180° scale. The marking arm may then be moved completely around the pipe. The marking is done by a special chalk that will not blow off and is easy to follow. The protractor is rigid in marking position and scribes a true line. Construction is of cast aluminum alloy. Four models handle pipe up to 3, 6, 12 and 36 inches, respectively.

NEW PORTABLE ACETYLENE GENERATOR

A new acetylene generator, known as the Oxweld MP-9 Medium-Pressure Acetylene Generator, and designed to combine portability with the operating advantages usually found only in larger units, has just been announced by The Linde Air Products Company.

Ample Acetylene

The MP-9 weighs only 129 lb., and can readily be moved about the shop or in the field. It holds 25 lb. of size 14ND Union



The Oxweld MP-9 Medium-Pressure Acetylene Generator

Carbide and will deliver as much as 50 cu. ft. of acetylene per hour at any desired pressure up to 15 lb. per sq. in. Several hours of continuous welding or cutting on all except the heaviest work can be obtained from one charging.

CUSHION FOR GOGGLES

A comfort cushion pad has been developed to alleviate the discomfort of wearing goggles on industrial operations such as preheating, metal pouring, relining open hearths and heavy gas welding and where the intense heats are conducted to the wearer's face through the eye cups of molded plastic goggles. This cushion pad, molded from soft sponge rubber, fits over the eye cups of Cesco chipping and welding type goggles. The rubber pad insulates the plastic goggles from the wearer's face, preventing blister and burns. When snapped over the eye cup, the elasticity of the rubber holds the pad securely in place without cementing or sewing. Pads can be sterilized and are readily replaced when necessary. The Chicago Eye Shield Company, 2300 Warren Boulevard, Chicago, Illinois.

SAFETY CATALOG

American Optical Company, Southbridge, Mass., announces its new industrial safety equipment catalog is now available and will be mailed on request without obligation. The catalog describes in detail the concern's complete line of eye, head and lung protective equipment, and also its new line of safety clothing. Industrial protection from head to ankles is provided.

The new catalog is the most complete ever issued by the optical concern. Among the items described are goggles for protection against impact, glare, splashes of liquids, particles of dust; welding helmets, face shields and respirators; and safety gloves, suits, sleevelets, leggings, aprons, hats and hoods.

GENERAL ELECTRIC PUBLISHES NEW ARC WELDING MANUAL

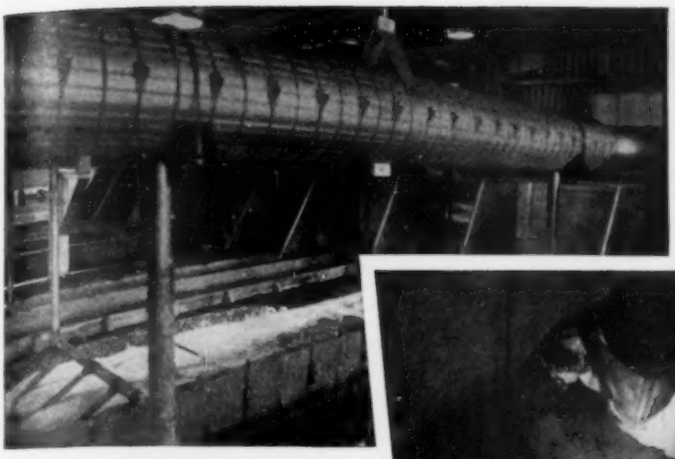
A pocket-size arc-welding manual, containing over 180 pages of useful information for welding operators, has just been published by General Electric. The book contains chapters on the technique and applications of arc welding, automatic arc welding, and atomic hydrogen arc welding, as well as 15 lessons in the art of welding which form a practical course for potential operators. In addition, the book, which is spirally bound, includes tables of useful information, a handy electrode estimator, and helpful hints on the selection of arc welding equipment. Price $1.00.

DUST THE DESTROYER

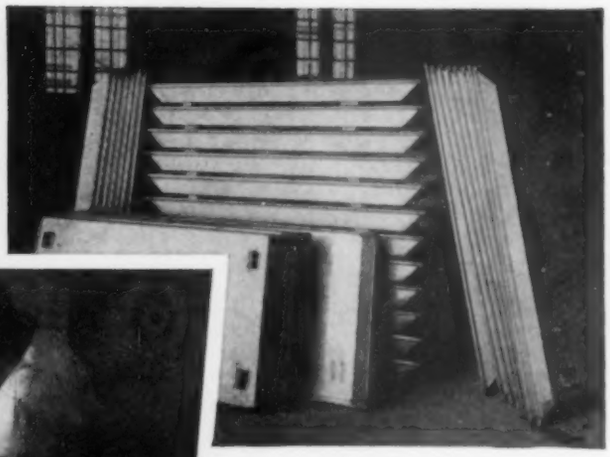
"Dust the Destroyer," a booklet designed to inform users of Motor Control about the advantages of Cutler-Hammer Vertical Contacts.

Every man who has the job of keeping electrical equipment operating knows that nothing causes as much trouble as burned, pitted, sticky contacts. What causes contact troubles? DUST burns'em up. . .

Copy will be furnished upon request by Cutler-Hammer, Inc., Milwaukee, Wis.



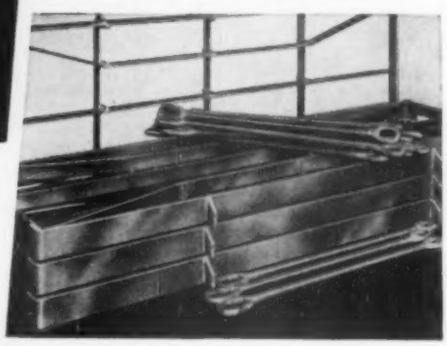
PAPER STOCK TROUGHS: A large southern Kraft mill made three 60-foot long x 24″ x 26″ stock troughs from 16 gauge Monel sheet. In each trough, 2 longitudinal welds, 5 girth welds and 2 end welds were made. No. 130X Monel rod was used throughout.



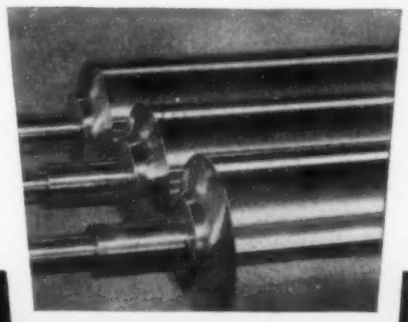
DRYING TRAYS: Monel trays 60 in. long by 20 in. wide welded from .078 in. gauge Monel using No. 130X. Suited for many drying problems, they resist sulfuric, phosphoric and other acids at high temperatures, and contact with absorbents in the presence of electrolytes.

COVERED ROLLS: Covering rolls with Monel by electric welding using No. 130X rod. Patent-protected process developed by Youngstown Welding and Engineering Company of Youngstown, Ohio. Finished rolls are shown below.

VARNISH KETTLES: Monel Varnish kettles are regularly welded with No. 130X Monel rod. Old copper varnish kettles are generally re-bottomed with Monel. Lower sections of those illustrated are 14 gauge Monel, bronze welded to upper copper sections. Bottoms are 7 gauge Monel. All Monel to Monel joints employ No. 130X Monel rod.



PICKLING CRATES: These welded Monel pickling crates safely handle payloads 14 times their own weight. The crates weigh 550 lbs. each, hooks 28½ lbs. each. Crates designed for a load of 8,000 lbs. of strip steel in coil. All-welded construction using No. 130X Monel metallic arc rod assures resistance to corrosion and lasting strength.



IT'S EASY TO WELD MONEL . .

. . . when you use No. 130X Monel Metallic Arc Welding Rod

Metallic arc welding of Monel to Monel, Monel to steel, or Nickel to steel, is easy. How do you do it? Use No. 130X rod, and follow these pointers:

1. Reverse polarity...work negative, electrode positive.

2. Use lower heat than for same work in steel. Run trial bead on scrap to get right heat.

3. On sheet up to 10 gauge a single bead gives complete penetration from one side, without veeing and with or without a suitable backing.

4. It is advisable to oscillate or weave welding rod on sheet heavier than 12 or 13 gauge.

5. Draw edge of flat chisel along edge of weld to remove flux after welding.

Write for "The Electric Welding of Monel and Nickel." Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

"Monel" is a registered trade-mark of The International Nickel Company, Inc., which is applied to a nickel alloy containing approximately two-thirds nickel and one-third copper.

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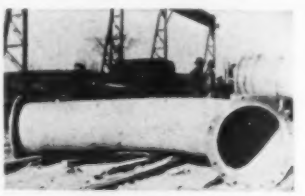
Thus far, twenty-eight different electrodes for "now standardized analyses" are produced by Arcos, and are available from stock. In the history behind these 28 electrodes, Arcos has sometimes been the experimental pioneer producing electrodes *before* an actual need; at other times we have been called in by industry to make *the* welding rod to solve a particular problem.



Arc Welding 18" Stainless Pipe with Chromend K

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a NEW single-pole control arc welding generator

Wilson, a pioneer manufacturer of arc welding machines, now presents the "Hornet" . . . a new line of welders which has the smoothest, steadiest arc obtainable with a welding generator. The "Hornet" assures uniform, smooth, uninterrupted current flow . . . gives quick recovery . . . absolutely prevents accidental reversal of polarity. This assurance of an unvarying current flow enables the "man in the helmet" to give undivided attention to his work . . . to make better welds.

The "Hornet" is compact, streamlined, and light in weight. Controls are greatly simplified and centrally located. The new "Hornet" is available in 200 ampere, 300 ampere and 400 ampere motor generator units—all "Hornets" liberally meet NEMA standards in every respect. Write for full information and a copy of the new "Hornet" booklet on . . . "the machine that stings high welding costs."

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A complete line of welding products.

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The Answer to Spot Welding in "Hard to Get at" Places...

Here's a holder that has won the plaudits of large spot welding users as a major advancement in the resistance welding field. It has been engineered with the utmost care and constructed of materials especially selected for high strength, high conductivity and resistance to wear.

One of the best-liked features of this Universal Off-Set Holder is the *Tip Knock-Out Device* which completely eliminates the difficulties often encountered in removing replaceable tapered shank tips.

Write today for complete specifications and prices.

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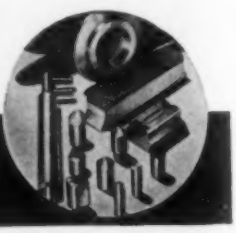
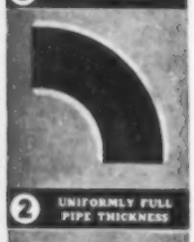


P.R. MALLORY & CO. Inc.
MALLORY



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WELDELLS are engineered down to the final detail to enable you to do a far better pipe welding job in far less time.

Less time is required to get the job under way because the name, size and weight is rolled into every Taylor Forge Fitting.

Less time is required to do the welding because the ends are marked at four 90° intervals to facilitate lining up, and because the ample tangents and clean, accurate machine tool bevels assure a quick but sound weld.

Forged and formed seamless and selectively reinforced in the zones where greatest strains occur, WeldELLS are the strongest part of any pipe system.

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The Taylor Forge line contains the largest range of seamless steel welding fittings made. It also covers welding flanges and welding nozzles for pressure vessels in a complete range of types and sizes.

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HIGH ALLOY STEELS

The Welding Research Committee, Industrial Research Division, announces that it has appointed Dr. S. L. Hoyt of Battelle Memorial Institute, Columbus, Ohio, as Chairman of Committee IV, on High Alloy Steels. Dr. Hoyt will present to the Committee a wealth of experience in this field. He has already gained an enviable reputation for his ability as a research worker and as an executive in handling research problems.

WELDABILITY

A round table conference on weldability and methods of testing for weldability will be held on Oct. 23rd at 8:15 P.M., Stevens Hotel, Chicago.

NEW APPOINTMENT

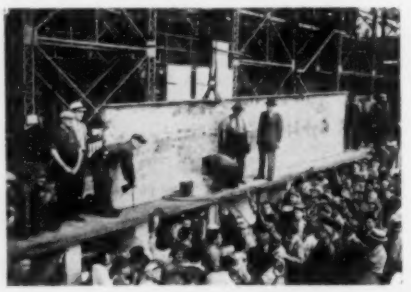
Of considerable interest to the welding industry is the recent announcement of the appointment of Mr. C. T. Price to the post of Vice-President and General Manager of the Compressed Industrial Gases, Inc., Chicago, Illinois. Mr. Price held the post of Vice-President in Charge of Sales until the recent action of the Board of Directors.

In his new position Mr. Price now has full charge of all operations of the company and directs the activities of all departments.

Mr. H. B. Pearson, Jr., has been advanced to the position of Secretary and Treasurer and the New General Accountant is Mr. G. R. Kall.

U. S. S. SOUTH DAKOTA

The photograph shows the laying of the keel for the thirty-five thousand ton battleship U. S. S. SOUTH DAKOTA which took place at the plant of the New York Shipbuilding Corporation, Camden, New Jersey, July 5, 1939.



Although these new battleships are far from being all welded, this is a keel laying in the modern manner in that, instead of driving the first rivet, it was officially laid down by striking the first arc.

H. K. PORTER CO.

The H. K. Porter Company, Inc., known for more than 70 years as manufacturers of industrial and switching locomotives, recently has expanded its activities by the establishment of a separate division for the design and manufacture of many types of processing equipment, including ball and pebble mills, tube mills, agitators, mixers, blenders, autoclaves, kettles, tanks, etc. Several of these products incorporate new features of design and construction developed by the company's process equipment engineering department.

Principal among the features found in Porter ball and pebble mills are the following:

All mills are mounted on self-aligning roller bearings of high load capacity designed to outlast the mill proper without attention other than lubrication. This reduction in friction load is said to materially reduce operating and maintenance cost.

All mill stands are of electrically welded steel construction to support the loads and maintain rigidity. The motor stands are fabricated as an integral unit of the mill stand to avoid misalignment of motor drive.

All drives are designed to meet the service required and have been selected for high overhung load capacity to minimize bearing wear in the drives themselves due to the spreading effect of gear and pinion loads.

It is stated that the only cast iron used in the construction of Porter mills is in the door and door frame which do not come in contact with the material being ground. Mill end castings and gears are of steel.

CIG

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See the combined exhibits of the HOLLUP CORPORATION and COMPRESSED INDUSTRIAL GASES, INC., at the NATIONAL METAL CONGRESS AND EXPOSITION.

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SUREWELD DEMONSTRATIONS

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Everything for Electric and Oxy-acetylene Welding

"I'm Bringing My Best Men"

"It's a business proposition with me — bringing my best men to the National Metal Congress and Exposition for the week of October 23rd. I know my men will pick up enough information about new products and processes to more than pay their expenses on the trip.

"Why, one of my men heard a paper delivered at the Congress last year that cleared up a machining problem that had us stumped for four months. And another of my boys last year came home with a whole note-book full of ideas he had jotted down after seeing the exhibits at the Metal Show — ideas that made our production 20% more efficient than last year.

"I find it's a good thing for my younger men to get to the Metal Show for at least a couple of days, too. It gives them a broader vision in their work here at our plant — and makes them more valuable to me, and themselves.

"You can bet that I'll be on hand at Chicago for the week of October 23rd — I don't want my boys to know more about recent developments than their president."

National
METAL CONGRESS *and* **EXPOSITION**
INTERNATIONAL AMPHITHEATRE
CHICAGO ····· Oct., 23-27, 1939

WELDED TRUCKS

This fleet of 18 Model M7 FWD trucks was recently delivered to the New York State Department of Public Works. These trucks have been distributed to various districts in New York State and will be operated the year 'round in highway work, including snow removal. Each unit is equipped with a $4^1/_2$ cubic yard dump body operated by mechanical hoist. Welding played an important part in the construction of these trucks.

CONTEST

The Second Annual Instrumentation Contest with a first prize of $200.00 in cash is announced by the Industrial Instrument Section of Scientific Apparatus Makers of America.

Twelve prizes in all, totaling $500.00, will be awarded. The contest is open to any person not employed by an instrument manufacturer. Two themes are specified: I.—Instruments Save Money; II.—Instrumentation Makes Jobs. The contestant is to submit either (*a*) an original report or (*b*) an original essay in support of either theme I or theme II. No manuscript should cover both themes.

The contest will be judged by the following Jury of Award: M. F. Behar (Editor, *Instruments*), C. S. Redding (President, Leeds & Northrup Co.), H. B. Richmond (Treasurer, General Radio Co.), P. T. Sprague (President, The Hays Corp., and Chairman, Industrial Instrument Section S. A. M. A.), L. G. Wilson (President, Precision Thermometer & Instrument Co.) F. K. Taylor (Vice-President, Taylor Instrument Cos.), Clemann Withers (Treasurer, Sperry Gyroscope Co.).

The contest closes November 15, 1939, and the judging will be held promptly.

Copies of the contest rules and official entry forms can be obtained from Scientific Apparatus Makers of America, 20 North Wacker Drive, R. 3014, Chicago, Ill.

TRAVELER

(*From the New York Sun*)

A correspondent, aboard the Dixie, of the Morgan Line, drops us a note from New Orleans to tell of a fellow traveler. On the ship, occupying a deck chair next to him, is F. T. Llewellyn of Pittsburgh. Mr. Llewellyn, recently retired from the U. S. Steel Co., has purchased fifteen consecutive round trip tickets on the Dixie. It seems that he not only loves the sea but that he has grandchildren in both New Orleans and New York. Fortified by his fifteen tickets he plans to just ride back and forth, dropping in to see the youngsters whenever he is in one of the two ports.

THE WELDING TORCH IN A NEW RÔLE

One of our members, Mr. Joseph Holt of Seattle, Washington, writes of his continued success in the scientific application of the heat of the welding torch in straightening all sorts of deformed pieces of steel. A few examples are shown below.

Mr. Holt refers to his method as the "contraction method." He has used this method to straighten power shovel booms, dippersticks, heavy structural members, steel bridge portals, batter-posts, windbraces and cords without removal from original positions. Other bridge parts have also been repaired in place with no hold-up of traffic.

Fig. 1—Shows a Windbrace After It Had Been Hit by the Boom of a "Power Shovel." Someone Had Forgotten to Lower the Boom After Loading It on a Trailer for Transportation. On the Member Marked "A" Some Force Was Used to Hasten the Work Rather Than to Wait for the Entire Cooling. On All the Other Members Nothing but the Torch Flame Was Used

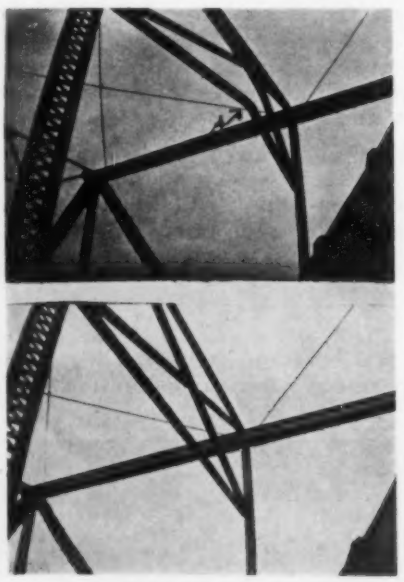

Fig. 2—Shows the Completed Task. Both the Compression Posts and the Windbrace Responded Very Nicely to the Torch

Fig. 3—Shows the Main Frame of a Trailer Made Up of H Beams Whose Flanges are 1 In. Thick. The Trailer Sagged from Improper Welding When Loaded. Two Torches Straightened It in a Few Hours. Internal Stresses Were Removed or Offset

Fig. 4—Shows the Completed Job

Fig. 5—Involves the Problem of Straightening a Heavy Steel Member Known as a Spud Used on a Gold Dredge. The Spud Was Made Up as a Box Member from Four 15-In. I Beams and Two ¾ In. by 24-In. Plates. It Had an Outside Dimension of 32 In. by 24 In. and a Total Length of 80 Ft. and Weighed Approximately 12 Tons. Two Men with Torches Straightened This Member in a Day and a Half Without Bringing Any Part of the Metal to More Than a Dull Cherry Red Heat and Without Applying Any External Force Whatever

Fig. 6—Shows the Completed Spud

Sections AMERICAN WELDING SOCIETY

CHAIRMEN, SECRETARIES AND REGULAR MEETING DATES

BIRMINGHAM — 3rd Fri.
CHAIRMAN—J. W. ADAMS, 209 No. 52nd St., Birmingham, Ala.
SECRETARY-TREAS.—W. L. POOLE, Air Reduction Sales Company, 2825 No. 29th Ave., Birmingham

BOSTON — 3rd Mon.
CHAIRMAN—F. B. MEHAFFEY, Air Reduction Sales Co., 122 Mt. Vernon St., Upham Crs., Dorchester, Mass.
SECRETARY—P. N. RUGG, 16 Fairmount Ave., Wakefield, Mass.

CANTON, OHIO (Akron, Alliance, etc.)
ROBERT M. WALLACE, The Griscom-Russell Company, Massillon, Ohio

CHATTANOOGA, TENN. — 1st Wed.
CHAIRMAN—CHESTER RAYMO, Chattanooga Boiler and Tank Company, 1011 East Main Street, Chattanooga
SECRETARY—A. R. MCLAIN, 622 Georgia Avenue, Chattanooga, Tenn.

CHICAGO — 3rd Fri.
CHAIRMAN—E. A. BALSLEY, Link-Belt Co.
SECRETARY—M. S. HENDRICKS, Room 731, 506 South Wabash Avenue

CINCINNATI, OHIO
CHAIRMAN—JAMES K. ROSS, United Welding Co., Box 247, Cincinnati, Ohio.
SECRETARY—LEWIS B. BLAKENEY, Westinghouse E. & M. Co., 207 N. 3rd St., Cincinnati, Ohio

CLEVELAND — 2nd Wed.
CHAIRMAN—F. L. PLUMMER, Consulting Engr., 914 Standard Bldg.
SECRETARY-TREAS.—A. LESLIE PFEIL, Universal Power Corporation

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CHAIRMAN—J. H. JOHNSON, Johnson Supply Co., Denver, Colo.
SECRETARY-TREAS.—H. W. CREAGER, Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.

COLUMBUS, OHIO
CHAIRMAN—F. S. CALDWELL, Jeffrey Mfg. Co., Columbus, Ohio
SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

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CHAIRMAN—JOHN J. VREELAND, Chase Brass & Copper Co., Waterbury, Conn.
SECRETARY—H. A. PENNINGTON, A. B. King & Co., 196 Chapel Street, New Haven

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SECRETARY—O. L. SMITH, Weldit Acetylene Co. 638 Bagley, Detroit

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CHAIRMAN—D. B. HUNT, P. O. Box 4564, Atlanta, Ga.
SECRETARY—H. J. LEE, P. O. Box 4564, Atlanta, Ga.

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CHAIRMAN—ROBERT A. PLAUS, W. A. Ramsay, Ltd., Honolulu, T. H.
SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., P. O. Box 2454, Honolulu, T. H.

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SECRETARY—R. D. EAGLESFIELD, JR., 300 So. La Salle St.

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CHAIRMAN—J. L. FIZZELL, National Steel Prods. Co., Kansas City, Mo.
SECRETARY—JIM KIRK, Air Reduction Sales Co., Kansas City, Mo.

LOS ANGELES — 3rd Thurs.
CHAIRMAN—C. P. SANDER, Western Pipe & Steel Co., Los Angeles, Calif.
SECRETARY, J. C. GOWING, 644 E. Florence Ave., Los Angeles, Calif.

LOUISIANA — 1st Fri.
CHAIRMAN—O. B. MCLAUGHLAN, Freeport Sulphur Co., Port Sulphur La.
SECRETARY—CLYDE PINE, The Isaac Delgado Trade School, New Orleans, La.

MARYLAND — 3rd Fri. except April
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SECRETARY-TREAS.—R. A. MANSFIELD, Southern Oxygen Co., Baltimore, Md.

MEMPHIS
CHAIRMAN—E. H. GILL, National Butane Co., Memphis, Tenn.
SECRETARY—B. B. DRURY, JR., National Cylinder Gas Co., Memphis, Tenn.

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CHAIRMAN—R. W. STERNKE, Lakeside Bridge & Steel Co.
SECRETARY—GILBERT F. MEYER, Machinery & Welder Corp.

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CHAIRMAN—WM. GALLOWAY, 4407-B, Fort Peck, Mont.
SECRETARY—H. S. GRIFFITH, Box 1787, Fort Peck, Mont.

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SECRETARY—G. V. SLOTTMAN, Air Reduction Sales Co., 60 East 42nd Street

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CHAIRMAN—T. J. WARMINGTON, Wm. Bros. Boiler & Mfg. Co.
SECRETARY—ALEXIS CASWELL, Manufacturers Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis

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SECRETARY—G. A. ROSS, General Electric Co., Schenectady, N. Y.

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SECRETARY—C. S. FREEMAN, The Lincoln Electric Company, Buffalo, N. Y.

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CHAIRMAN—K. B. BANES, P. O. Box 1377, Okla. City, Okla.
SECRETARY—C. C. WILLIS, P. O. Box 1498, Oklahoma City.

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CHAIRMAN—L. B. THOMAS, Economy Welding Service, 18th & Cuning Sts., Omaha
SECRETARY—G. E. MCGRATH, McGrath Welding Co., 4026 Nicholas, Omaha

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SECRETARY—W. J. BROOKING, R. G. LeTourneau, Inc., Peoria, Ill.

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SECRETARY—H. E. HOPKINS, Arcos Corp., 401 N. Broad St.

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CHAIRMAN—G. F. WOLFE, Dravo Corp., Engineering Wks Div., Pittsburgh, Pa.
SECRETARY—J. F. MINNOTTE, Minnotte Bros., 1201 House Bldg.

PUGET SOUND
CHAIRMAN—H. HAYNES, 53 Lander St., Seattle, Washington
SECRETARY—L. A. BURQUE, Westinghouse Elec. & Mfg. Co., Seattle, Washington

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SECRETARY—J. W. SHUGARS, Lincoln Elec. Co., Moline, Illinois

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CHAIRMAN—T. R. ROONEY, Western Pipe & Steel Co.
SECRETARY—J. G. BOLLINGER, Air Reduction Sales, Park & Halleck Sts., Emeryville, Calif.

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SECRETARY—JAMES BRIDGES, Box 442, Bakersfield, Calif.

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SECRETARY—M. E. MEYERSON, 2317 Chouteau Ave., St. Louis, Mo.

SOUTH TEXAS
CHAIRMAN—L. H. COURTRIGHT, Reed Roller Bit Co., Houston, Texas
SECRETARY—G. V. DYE, G. V. Dye Co., Houston

TULSA, OKLAHOMA
CHAIRMAN—G. L. WILEY, Box 226, W. Tulsa, Okla.
SECRETARY—O. L. ROGERS, Big Three Welding & Equipment Company, Tulsa, Okla.

YOUNGSTOWN (OHIO) — 2nd Mon.
CHAIRMAN—E. W. TROSS, United Eng. & Fdy. Co., Youngstown
SECRETARY-TREAS.—C. R. RIGGLE, Ohio Edison Co., Youngstown

WASHINGTON, D. C. — 2nd Tues.
CHAIRMAN—C. A. LOOMIS, Bureau of C. & R., Navy Dept.
SECRETARY—G. E. KNOX, Bureau of Yards & Docks, Navy Dept.

WICHITA, KANSAS
CHAIRMAN—L. E. KIRK, Vickers Petroleum Co., Wichita, Kansas
SECRETARY-TREAS.—K. O. HOUSER, Kansas Gas & Electric Co., Wichita, Kansas

WELDING STAINLESS-CLAD STEEL

The Composite Steel Division of the Jessop Steel Co., 628 Green St., Washington, Pa., has recently perfected a new method of welding stainless-clad steel that eliminates any danger of reduction in corrosion resistance in the weld zone. In the past, some difficulty has been found in welding stainless-clad steel, due to the admixture of mild steel with stainless steel in the weld zone. This often occurred even when stainless rods were used throughout.

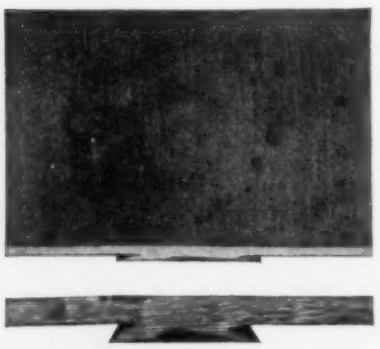


Fig. 1—(Top of Cut) Top View Showing Cladding on Piece of Welded Stainless-Clad Steel, Which Has Been Subjected to Salt Spray Test. (Bottom of Cut) Cross Sectional View of Same Piece

The new method of welding stainless-clad steel maintains the full corrosion resistance of the weld zone, even when a mild steel rod is used for welding the backing. Figure 1 is an unretouched photograph (top and cross sectional view) of a piece of welded Silver-Ply, a stainless-clad steel manufactured by the Jessop Steel Company, which test piece has been subjected to a 24-hour exposure of a 20% salt spray mist at Pittsburgh Testing Laboratory. It will be noted from top view, that there is no more corrosion in the weld zone than in adjacent parts of the piece.

Figure 2 illustrates the procedure for welding stainless-clad steel by the new method. Figure 2*A* shows the plate as supplied, the lined portion representing the cladding. The plate is then scarfed and the cladding bent down with a follow-up tool or hammer, as illustrated in Fig. 2*B*. The primary weld (bead No. 1—Fig. 2*C*) is made with a $^1/_8$ inch diameter stainless steel coated rod at the juncture of the two claddings. The two plates are then turned over and secondary welds made on underside of exposed cladding, as indicated in Fig. 2*D*, using a $^3/_{16}$ inch diameter stainless steel coated rod. The final weld (joining the mild steel backing) may be made with a $^1/_4$ inch diameter mild steel coated rod. Figure 2*E* represents the completed weld; bead No. 1 is then ground flat with the cladding.

In all cases where stainless rods are used, the rod should be richer in alloy than the cladding. Lowest possible amperage and fastest possible welding time are recommended.

The procedure outlined permits great savings in cost of rods, since mild steel may be used to weld the backing.

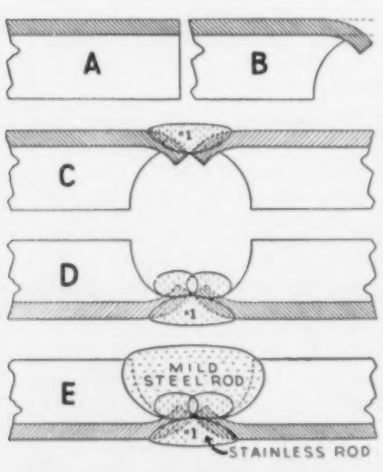


Fig. 2—Steps in the New Method of Welding Stainless-Clad Steel

MUREX DISTRIBUTOR

The Mine & Smelter Supply Company, with headquarters at 1422 Seventeenth Street, Denver, Colorado, has recently been appointed distributor for Murex Welding Electrodes, manufactured by the Metal & Thermit Corporation.

Mine & Smelter will serve the state of Colorado, most of the state of Wyoming, the southwestern portion of South Dakota, the northwestern portion of Nebraska and the northern part of New Mexico.

The Murex line includes electrodes for welding mild steel in all positions, and for high-class down-hand work for welding Manganese, Stainless, Carbon-Molybdenum, Cor-Ten, Mayari, Cromansil, High Carbon, and Nickel Steels, and for hard surfacing plain Carbon steels. All are of the heavy-coated type that economically produce high quality weld metal, and complete stocks will be carried by the Mine & Smelter.

WELD REPAIR

This furnace is a good illustration of the versatility of the application of welding to maintenance and repair work. Cracks in the outside shell, as well as the iron door frame, were repaired without putting out the fire in the furnace or dismantling any part of it.

Photo Courtesy Westinghouse Elec. & Mfg. Co.

SCRAPER

This 8-ton hauling scraper was constructed entirely from welded rolled-steel plates and sections, except for the pneumatic loading device. Designed to self-load 8 cubic yards of dirt and haul 9.7 yards, the scraper was built by Litchfield Machine Shop, Litchfield, Minn., and has a total weight, loaded, of about 20 tons. Users report that the machine has hauled thousands of tons of dirt without failure of a single weld.

Photo Courtesy Westinghouse Elec. & Mfg. Co.

NEW OXYACETYLENE BOOK

A new book has recently been published entitled, "Oxyacetylene Welding Repair Manual" for garage and repair shop welders, maintenance engineers and automobile and aircraft sheet metal workers. The authors are C. G. Bainbridge and F. Clark. The book was printed and published by Porteous Ltd., Imperial Works, Leman Street, London, E.1. The book consists of 245 pages copiously illustrated.

NEW 500 AMPERE AC WELDER

The Hampton Electric Tool Company 700 Walnut Street, Edgewood, Pittsburgh, have recently added to their line of AC Electric welders, a new model known as "E2F." This welder is designed to operate on either 220 or 440 volts; it can be operated by two operators simultaneously from 30 to 280 amperes each and by simply shifting a copper bar on top of the welder it can can be operated by one operator from 30 to 560 amperes.

Visit
METAL SHOW
Chicago
Oct. 23–27

CHAMPION

Establishes

New Standards of Quality in WELDING ELECTRODES

Champion electrodes are quality electrodes. They are designed to meet the requirements of America's leading manufacturers of quality products. Champion's many years of specialized fabricating experience thus finds expression through a superior welding electrode in the production of many of today's blue ribbon examples of modern industry. Champion serves where engineering demands the utmost; where design is all important; or wherever quality of finished product requires like quality in its essential materials.

Champion customers who X-ray each finished weld, and subject their products regularly to every conceivable test, buy only on the basis of proven facts. They buy Champions with confidence born of long satisfaction.

All steel used by Champion is "tailor made" to exact specifications. Re-analysis of all chemicals used for coating is regular procedure. Actual welding tests are made of finished electrodes. A serial number identifies each heat of wire. Samples of all electrodes shipped are held on file completing the history of every order.

These are the precautions of experience—precautions that mean consistently better electrodes for consistently better welds. . . . The Champion Rivet Company, Cleveland, Ohio; East Chicago, Indiana.

Champion Welding Electrodes are packed in a heavy corrugated cardboard shipping container which is sealed on all sides. An imbedded wire with handy loop lets package zip open.

CONTROLLED QUALITY

» » » SECTION ACTIVITIES « « «

BIRMINGHAM

The Birmingham Section announces the election of the following officers for the ensuing year:

Chairman—Julien W. Adams.
Vice-Chairman—C. R. Tinsley.
Secretary-Treasurer—W. L. Poole.
Executive Committee—W. P. McCutcheon, Paul Wright, C. C. Pinckney, F. E. McAtee, E. E. Michaels, J. E. Durstine, J. B. McCaghren, C. E. Korner.

CINCINNATI

The regular meeting of the Cincinnati Section was held on June 14th in the local Warehouse of Williams & Company, Inc., who acted as hosts at the conclusion of the meeting.

Mr. J. R. Hunter of the Revere Copper & Brass Company located in Rome, N. Y., gave an illustrated talk under the subject, "Practical Welding of Copper and Alloys." Demonstrations were also made of several types of specimens.

The annual meeting of the Section was also held before the regular June meeting and the following officers were elected:

Chairman—James K. Ross.
Vice-Chairman—Eric O'Hara.
Treasurer—W. A. Maddox.
Secretary—L. B. Blakeney.
Directors (2 years)—R. L. Kirby, G. F. Lockeman, F. L. Meacham.
Member of Executive Committee (1 year)—F. H. Smith.

A good attendance was on hand and thoroughly enjoyed the evening.

CLEVELAND

The October meeting was held on the 11th at Fenn College. Mr. Elmer Isgren of LeTourneau, Inc., Peoria, Ill., spoke on "Arc Welding Road Equipment."

The Cleveland Section will sponsor a Fall Educational Lecture Course to be delivered by Mr. Walter Davis, Welding Engineer of Cleveland Railway Company. The general subject of his lecture will be "The Welding of Some Important Commercial Metals." Lectures will be delivered at Fenn College at 8:00 o'clock on the following dates and will have the following sub-titles:

October 16th—"Welding Fundamentals and General Considerations."
October 23rd—"Welding Plain Carbon Steels and Other Ferrous Metals."
October 30th—"Welding Low Alloy Steels."
November 6th—"Welding High Alloy Steels."
November 13th—"Welding Non-Ferrous Metals."
November 20th—"Welding Non-Ferrous Metals."

The Cleveland Section advises that Mr. L. H. Frost, Educational Chairman, has been made District Manager at Detroit for the Thomson-Gibb Electric Welding Company.

DETROIT

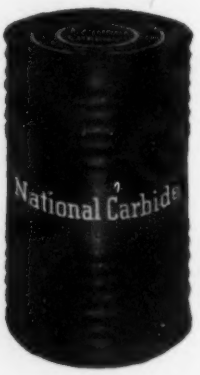
The Detroit Section announces the election of the following officers and executive committee for the fiscal year:

Chairman—H. P. Doud.
Vice-Chairman—G. N. Sieger.
Secretary-Treasurer—O. R. Smith.
Executive Committee (2 years)— A. H. Lewis, E. H. Foss.

HAWAII

At the May 25th meeting of the Ha-

National
Carbide



DEPENDABLE
EFFICIENT
ECONOMICAL

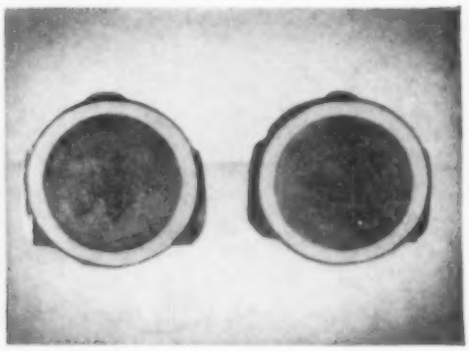
FOR WELDING and CUTTING
Use National Carbide in the Red Drum
NATIONAL CARBIDE CORPORATION
Lincoln Building
New York, N. Y.

Hard-Facing in the Oil Fields

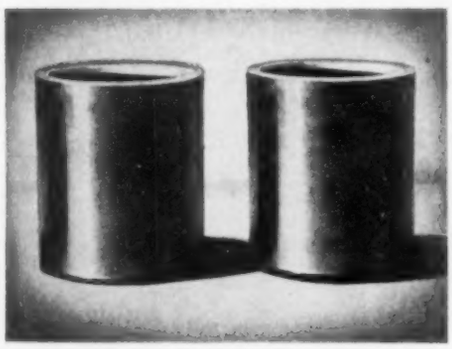
Haynes Stellite Alloy Reduces Wear and Saves Money

Applying Haynes Stellite hard-facing rod to a valve seat for an oil pipe line pump. The valves are also hard-faced.

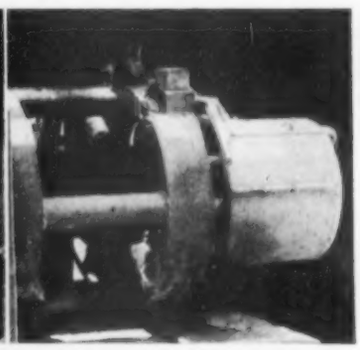
Exhaust valves and seats wearproofed with Haynes Stellite alloy were in good condition after 90 days' service in a 250 h.p. gas engine. Before hard-facing was adopted, these parts wore out in 20 days.



Disks for 7-in. Christmas tree valves, hard-faced with Haynes Stellite alloy, resist abrasive and corrosive crudes.



Refinery pump shaft sleeves, 8 in. O.D. by 11 in. long, protected from wear by Haynes Stellite hard-facing alloy.



This extrusion nozzle (left) is used in the apparatus shown (right) for coating oil pipe with a mastic of asphalt and mineral aggregate. Nozzles used to last 18 hr. but this hard-faced one will last indefinitely.

Write for the books, "Hard-Facing With Haynes Stellite Products," and "Haynes Stellite Products in the Oil Fields," which tell how these products can reduce wear and save money for you.

HAYNES STELLITE COMPANY

Unit of Union Carbide and Carbon Corporation

UCC

Chicago · Cleveland · Detroit · Houston · Los Angeles · New York · San Francisco · Tulsa

General Office and Works—Kokomo, Indiana

Foreign Sales Department—New York City

HAYNES STELLITE TRADE MARK

Red-hard, wear-resisting alloy of cobalt, chromium and tungsten

Haynes Stellite hard-facing rods and information on other Haynes Stellite Company products also are available through all apparatus shipping points of The Linde Air Products Company

"Haynes Stellite" is a registered trade-mark of Haynes Stellite Company.

See the display of valves hard-faced with Haynes Stellite alloy for resisting the action of high-pressure, high-temperature steam at Area L-305, National Metal Exposition, International Amphitheatre, Chicago, October 23–27, 1939.

waiian Section held at the Pacific Club, a movie on "Metal Spray Process" was shown. This was followed by an interesting round-table discussion of the many merits and uses of this relatively new field in welding.

At the June 29th meeting the results of the election of officers were announced as follows:

Chairman—Robert Plaus.

Vice-Chairman—Herman York.

Secretary-Treasurer—Alan G. Slipper.

Executive Committee (2 years)—C. M. Ryan, J. K. Mardick, John Wasson.

The films, "Pipe Line Welding" and "Comparisons of Welded Steel and Castings," were shown.

LOS ANGELES

In preparation for a new year of activity and with the expectation that great progress will be made on all fronts in that year, the executive board of the Los Angeles Section has appointed the following committees.

Program: C. W. Roberts, A. K. Brumbaugh, L. W. Horn, Joe Killiam, F. H. Stevenson, C. M. Allen.

Public Utilities: R. W. Reno, Lloyd Earl.

Membership: H. L. Newby, M. R. Daugherty, R. L. Graves, Stanley Levyn, Lorenzo Kennon, Frank Mant, E. A. Chandler.

Entertainment: H. P. Etter, Joe Killiam.

Educational: Alex Maradudin, Charles Haynes, Lloyd Earl, Turner C. Smith.

Codes and Specifications: E. L. MacDonald, Paul Jeffers, Harold Whittlesey, Turner C. Smith.

Publicity: C. L. Stocker.

MARYLAND

The Maryland Section Oyster Roast will be held in Baltimore, in October, definite date not as yet set.

November 17th meeting will be held at the Engineers' Club. Mr. Charles H. Jennings of the Westinghouse Elec. & Mfg. Company, will be the speaker.

Consolidated Gas & Electric Company of Baltimore is constructing a new addition to their Westport plant, all pipe lines welded and are carbon molybdenum.

The Silverdust Corporation, Lever Bros., Baltimore, is constructing large addition to plant, most all welded.

NEW YORK

The New York Section announces the appointment of the following committee chairmen:

Program—E. V. David.

Lecture Course—S. S. Scott.

Membership—G. N. Bull.

Finance and Budget—G. V. Slottman.

Special Activities—E. Vom Steeg.

By-Laws—J. B. Tinnon.

At a meeting of the Executive Committee on July 11th, the following tentative schedule for regular Section meetings for 1939–1940 season was drawn up:

Tuesday, Sept. 12th—"Welded Industrial Piping."

Wednesday, Nov. 15th—"Welded Pressure Vessels." (Joint Meeting with A. S. M. E.)

Tuesday, Dec. 20th—"Structural Steel Welding." (Joint Meeting with A. C. S. E.)

Tuesday, Jan. 9th—"Gas Machine Cutting."

Tuesday, Feb. 13th "Aircraft Welding."

Tuesday, March 12th—"Ship Welding." (Naval Architects and Marine Engineers invited.)

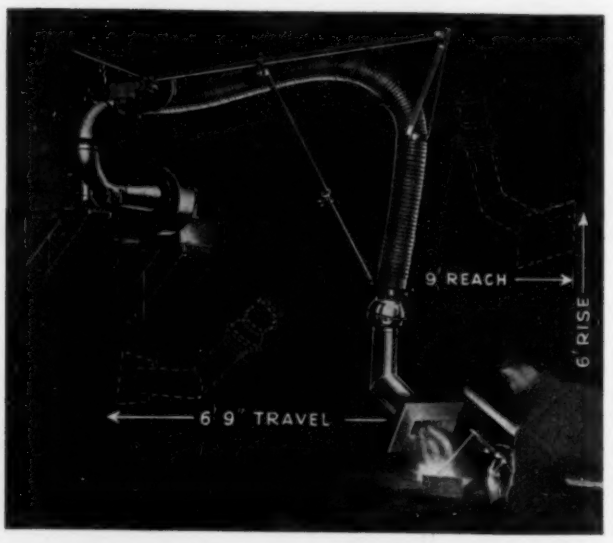
Tuesday, April 9th—"Weldability of Steels." (Joint Session with A. S. M. E.)

Tuesday, May 13th—"Flame Treatment of Steels."

Undoubtedly there will be some changes in the above set-up, as details of the individual programs are worked out. Revised programs will be published in later issues of the Journal.

A joint meeting of the New York Section, AMERICAN WELDING SOCIETY and New York Chapter, American Society for Metals, was held on Tuesday, September 12th, at 7:30 P. M. in the Engineering Societies Building. Mr. Edwin B. Ricketts, Mechanical Engineer, Consolidated Edison Company of New York, Inc., was chairman. A very interesting paper, entitled "The Selection and Application of High Temperature Piping Material," by Messrs. E. H. Krieg and G. Sonderman, Engineering Department, American Gas and Electric Service Corporation was presented. Mr. A. N. Kugler, Mechanical

RUEMELIN
WELDING FUME COLLECTOR



Effectively removes welding fumes at the source! Noxious smoke, gas and heat *can be* controlled with this proven equipment. . . . Leading manufacturers are sending us repeat orders, testifying to the practical results secured.

Write for Bulletin No. 37-C just released

RUEMELIN MFG. COMPANY
3881 North Palmer St. Milwaukee, Wisconsin

ANNUAL CONVENTION

CHICAGO

STEVENS HOTEL

Make reservations now for the following events:

Wednesday Evening

Stag Party, 10:00 P.M. to 1:00 A.M.—
Boulevard Room—Food, Entertainment,
Refreshments. Men only.
Admission $1.00
Order Tickets Now

Thursday Evening

Annual Banquet, 7:00 P.M.—Boulevard Room.
Toastmaster and Speaker of National Prominence—
Singing by Purdue University Glee Club
Music—Festival Winners
Dancing and Music by Don Fernando and his Orchestra
$4.00 per person

See the Welding Exhibitions, International Amphitheater, 43rd & Halsted Street

Bus service operating on a regular schedule between Hotel and International Amphitheater

Hours: 12:00 Noon to 10:00 P.M. daily except Thursday when it closes at 6:00 P.M.

—Don't Miss the Show—

Engineer, Applied Engineering Department, Air Reduction Sales Company, also gave an outstanding talk on "Recent Developments in Oxyacetylene Pipe Welding." The discussion which followed the papers was exceptionally good. Approximately 215 members of the two Societies attended the meeting. Refreshments were served after the meeting.

NORTHWEST

The following committees have been appointed to have charge of the various activities of the Northwest Section during the coming year:

Advisory: T. P. Hughes, Chairman, C. E. Comfort, G. W. Irwin, John Mikulak, John Nelson.

Acquaintance: H. A. Lindeke, Chairman, G. C. Hill, Fred Klass, Wm. E. Murphy.

Meetings: R. W. Robinson, Chairman, V. L. Sage.

Membership—Minneapolis: C. M. Akins, Chairman, Guy L. Pugh, C. E. Riebeth.

Membership—St. Paul: J. H. Barron, Chairman, W. H. Grohs, L. T. Kenny.

Program: R. H. Newton, Chairman, J. E. Williams.

Because of summer vacations and other distractions, the activities of the Section have been somewhat dormant. However, R. H. Newton, Chairman of the Program Committee, has been busily engaged in preparing the program for the coming season. From every indication the Section will be visited by a number of speakers who are recognized authorities in their respective fields. They will discuss questions of immediate importance in the art and science of welding. It is expected that the program committee, will schedule subjects of such interest that no member can afford to miss any of the meetings.

OKLAHOMA CITY

At an Executive Committee meeting on July 6th it was decided to change the meeting night of the Section from the first Tuesday to the first Friday.

The following officers and committees have been elected for the 1939–1940 season:

Chairman—K. B. Banks.
Vice-Chairman—W. H. Rice.
Treasurer—W. B. Klein.
Secretary—C. C. Willis.

Executive Committee—(1 year) J. M. Mideke, Clovis Gee, G. E. Day, C. C. Willis; (2 years) Chas. Bowen, L. E. Acker, O. T. Barnett, D. F. McCandlish.

Program Committee: O. T. Barnett, Chairman, Jos. M. Mideke, Howard Simms.

Membership: Francis Sprehe, Chairman, J. M. Crissman, W. D. Brewer.

Educational: Wm. Tiffin, Chairman, O. T. Barnett, J. Lang, Justin Roach, W. H. Rice.

The program for the coming season as now outlined is as follows:

October 6, 1939—Motion Picture, "A Story in Steel." Speaker—G. L. Wiley, Mid-Continent Petroleum Company and Chairman of the Tulsa Section. He will talk on the education of welders with particular regards to the latest welding trend. This being a dinner meeting, the after-dinner speaker will be R. L. Feagles, who will be remembered for his talk last year on the patented egg-marking device.

November 3, 1939—Motion Picture, "The Manufacture of Abrasives." Speaker—Jack Singleton, District Engineer of the American Institute of Steel Construction from Topeka, Kansas, who will talk on welding of bridges and buildings.

December 1, 1939—Motion Picture, "The Story of Lead Smelting." Speaker—Leon C. Bibber, Welding Engineer of the Carnegie-Illinois Steel Corporation, who will speak on "Welded Joints—Which Ones to Use and Why and When."

January 5, 1940—Motion Picture, "Evolution of the Oil Industry." Speaker—E. W. P. Smith of The Lincoln Electric Company. His talk will be on the subject of Expansion and Contraction.

February 2, 1940—Motion picture dealing with the sulphur industry. Speakers—D. R. Johnson and Earl K. Dewey, of the Continental Oil Company at Ponca City, who will talk on metal spray protection of refinery equipment.

March 1, 1940—Motion Picture, "Modern Metalworking with the Oxyacetylene Flame." Speaker—F. G. Flocke, of the International Nickel Company.

April 5, 1940—Motion Picture, "Aluminum—Fabricating Processes."

May 3, 1940—Motion Picture, "Through Oil Lands of Europe and Africa." Speaker—C. H. Jackman, of the metallurgical department of the Carnegie-Illinois Steel Corporation, who will talk on the welding of low-alloy steels.

June 6, 1940—This will be the third annual meeting, and instead of the motion picture, the Section will probably have another "beer bust." They have arranged for a speaker however, one who will make the meeting quite worthwhile; namely, E. R. Fish, Chief Engineer of the Hartford Steam Boiler Inspection and Insurance Company, who will talk on "WELDING—Past, Present and Future."

PHILADELPHIA

The regular monthly meeting of the Philadelphia Section was held on Monday, September 18th, at the Engineers club. Mr. Frederick H. Dill, Assistant to Mechanical Engineer, American Bridge Company, presented an interesting address on "Structural Steel Welding Progress."

The following is the schedule of meetings for the 1939–1940 season:

October 16, 1939—"Welding Fabrication of Stainless Steel."

November 20, 1939—"Industrial Pipe Welding."

January 15, 1940—"Fabrication of Pressure Vessels by Welding," The M. W. Kellogg Company.

February 17, 1940—"Electrodes and Weldability of Steel," A. O. Smith Corporation.

March 18, 1940—"Welding of Copper and Copper Base Alloys," "Gas Cutting and Fame Descaling."

April 15, 1940—"Welding in Marine Industry."

May 20, 1940—Inspection Trip.

The Section advises that the Dining Room of the Engineers' Club is open for dinner on the evening of the Section meetings. Meetings will be held at 8.00 P. M. at the club.

PITTSBURGH

The officers and executive committee elected for the fiscal year of the Pittsburgh Section are as follows:

Chairman—George F. Wolfe.
Vice-Chairman—A. E. Marble.
Secretary—J. F. Minnotte.

Executive Committee—(1 year) R. B. Lincoln, C. E. Loos, Milton Male; (2 years) R. C. Waldie, C. H. Jennings, Harry Thompson.

The opening meeting of the 1939–1940 Season of the Pittsburgh Section will be held Wednesday night, October 18th, in the auditorium of the beautiful Mellon Institute of Industrial Research, Oakland Pittsburgh, Pa.

Speakers of the evening and their subjects will be:

"Welding Problems in Stainless Steels in Transportation Equipment," Virgil Whitmer, Metallurgical Department, Republic Steel Corporation, Cleveland.

"Problems in Welding Low-Alloy High-Tensile Steels in Transportation Equipment," Howard L. Miller, Metallurgical Dept. (Alloy Div.), Republic Steel Corporation, Cleveland.

ST. LOUIS

The coming year promises to be very big for the St. Louis Section. Definite programs have been arranged for five meetings.

The first meeting of the season consisted of a visit to the Alton plant of the Owens-Illinois Glass Company. Two hundred and fifty members and guests made the inspection trip. The 67 people who took the "Welding Special" of the interurban line were treated to a cool ride as this was the hottest night of the summer.

EMPLOYMENT SERVICE BULLETIN

SERVICES AVAILABLE

A-322. Graduate Mechanical Engineer desires position. Organized Welding Department for large chemical company. Experienced in extending use of welding in new fields in connection with shielded electrode sales. Specialty supervising welding in alloy and stainless steels. Familiar with pressure vessel manufacture. Married. Willing to go anywhere.

A-323. Welding Engineer—14 years' experience, practical and technical, in all types of acetylene and electric welding and cutting, qualified A. S. M. E., electric and acetylene, in 1936. Experienced in design, production setup and control, supervision and the engineering of the latest methods of welding silver. Soldering and machine cutting. Age 31, American

born, married, health perfect. High school graduate with 3 years' extension courses. Willing to travel. References.

A-324. Professor desires position. Has two degrees, four years' teaching experience, and twelve years' industrial experience. Prefer teaching in welding, metallurgy, and shop. Would also appreciate consideration as a research engineer.

POSITIONS VACANT

United States Civil Service Examinations

Chief Engineering Draftsman, $2600 a year
Principal Engineering Draftsman, $2300 a year
Senior Engineering Draftsman, $2000 a year
Engineering Draftsman, $1800 a year
Assistant Engineering Draftsman, $1620 a year

For Work on Ships
Optional Branches

1. Electrical (Ship)
2. Hull structures, arrangements and fittings
3. Marine engines and Boilers
4. Piping (Ship)
5. Ventilation (Ship)

Applications may be filed with the United States Civil Service Commission at Washington, D. C., until further notice. Applications will be rated as received.

OXYACETYLENE WELDING FOR BEGINNERS

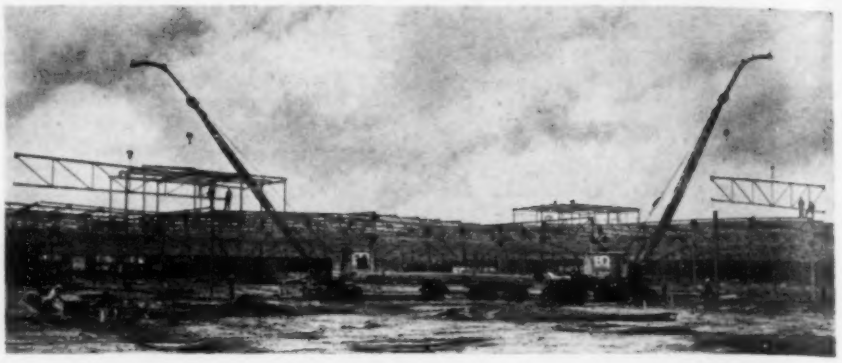
By J. W. Giachino

As indicated by the title, this book is distinctly for the *beginning* student of welding. The series of 23 lessons represents the scope of work which must be mastered before one can become an expert welder. Each is accompanied by a brief, clear explanation of needed apparatus, safeguards, use of tools, and methods of procedure, followed by questions which clinch the information presented in the given lesson. Each lesson is to be carried out in the order presented, with special effort taken to develop the necessary skill required for carrying on the work. The lessons have been subjected to class test, hence can be relied on.

AVIATION PLANT

The aviation industry's first completely controlled conditions plant, now being built at Indianapolis for the Allison Engineering Division of General Motors Corporation, is setting new speed records for the construction industry. Erection of steel was completed recently by The Austin Company, designers and builders of the structure, less than three weeks after they started field work on the project which will be the largest factory of its type in the world.

The new plant, having more than a quarter-million square feet, will be devoted to the manufacture and development of high-powered liquid-cooled aircraft engines and will be ready for occupancy by fall.



Twin Goosenecked Cranes Last Week Placed Final Structural Members for the Aviation Industry's First Completely Controlled Conditions Plant. The Austin Company Designed and Is Building This Structure for the Allison Engineering Division of the General Motors Corporation. With a Total of More Than a Quarter-Million Square Feet, It Will Be the World's Largest Controlled Conditions Plant

All the elements comprising a complete manufacturing and assembly layout for high precision work will be combined in a single, integrated unit. Air-conditioning, acoustical walls and complete light control giving uniform illumination 24 hours a day will provide ideal working conditions.

Incoming materials entering the plant at a receiving dock at the east end will move into production in two lines, one for ferrous and one for non-ferrous materials, along the north and south walls, while the press shop, welding department, heat-treating and other metal finishing will be located in between. These parts will move into the sub-assembly and final assembly as they move toward the west end where the shipping department will be located.

The plant will be entirely welded and will have face brick exterior with limestone trim incorporating striking modern lines. It will include a power plant equipped with Diesel engines capable of supplying all the power required for manufacturing and lighting.

SAFETY CONGRESS

The 28th National Safety Congress and Exposition, National Safety Council, will be held in Atlantic City, Oct. 16–20. Any member of the Society will be cordially welcome and will be extended all of the privileges of the Congress.

The program contains 140 separate meetings; over 500 officially scheduled participants; an enormous safety exposition; and brief details of the many illustrated lectures and demonstrations to be presented.

WELDING DIVISION

Creation of a new metal welding division and consolidation of machine shop activities in the main plant have been announced by Covered Wagon Company, Mount Clemens, Mich., trailer coach manufacturers. The new division was established to fabricate the wider trailer chassis frames of 1940 models, A. G. Sherman, president, said.

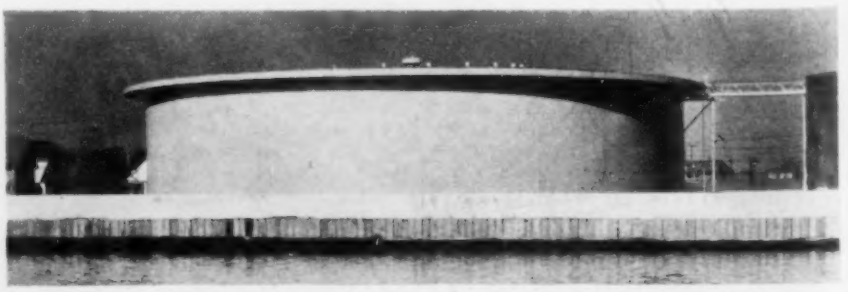
Complete facilities for manufacturing chassis frames on special pattern forms, for welding and riveting, and for construction of all metal parts used in Covered Wagon trailers have now been consolidated in the new division. Uniform mass production methods will provide more efficient manufacturing processes, Mr. Sherman said.

VISIT THE METAL SHOW

Chicago, Oct. 23–27

Latest Welding Developments

WELDED TANK



100,000-Bbl. Gasoline Storage Tank Equipped with a Wiggins Balloon Roof at Dearborn, Michigan. It Is 150 Ft. in Diameter by 32 Ft. High. The Wiggins Balloon Roof Flexes Up and Down, Taking Care of the Expansion and Contraction of the Vapor in the Tank Without Venting Any of It to the Atmosphere. This Prevents Evaporation Loss